TAMPEREEN TEKNILLINEN YLIOPISTO
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TAPANI SALMINEN

IMPROVEMENT OF PROCESS FOR MANAGING FIXED MANUFACTURING LEAD TIME PROMISES

Master of Science thesis

Examiners: Professor Kari T. Koskinen and Associate Professor Minna Lanz
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ABSTRACT

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Precise and reliable delivery promises are essential to manufacturing companies. A make-to-order or assemble-to-order company may make delivery time a strong competitive advantage. The case company, a Nordic high-tech electronics manufacturer, uses fixed manufacturing lead time promises (FMLTP) as a basis for delivery time promising.

This is a case study that aims at identifying the need of improving the actual FMLTPs of certain products as well as providing improvement suggestions for the process of managing the FMLTPs. In addition, the target of the study is to present alternative delivery time promising models; to analyze the impact of manufacturing environment decisions to delivery time promises; and to discuss the importance of delivery time for manufacturing companies.

To address these objectives a literature review and an extensive current state analysis were conducted. The analysis consists of semi-structured interviews, a quantitative sales data analysis and of a brief competitor benchmark study. 18 employees of the case case company were interviewed in order to understand the pros and cons as well as to identify the improvement possibilities in the current state of the FMLTP model. Sales data analysis enabled making data-based recommendations for improving the FMLTPs.

The results imply that the case company's delivery times are in general competitive but the FMLTP model causes additional unnecessary work and could be improved. The literature review suggests that supply chain resources based advanced-available-to-promise (AATP) model could be a promising alternative for the FMLTP model. Based on the results of the current state study, this thesis provides a list of the case company's products whose FMLTPs need improvement. Likewise, improvement suggestions for the process for managing FMLTPs are provided. Process related improvement suggestions are given for new product introduction (NPI) process to standardize and ensure justified FMLTP decisions. Additionally proposals are provided for reviewing the performance of the FMLTP model and revising the FMLTPs.

TIIVISTELMÄ

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Tarkat ja luotettavat toimitusaikalupaukset ovat erittäin tärkeitä tuotantoyrityksille. Tilauksesta valmistavat (engl. make-to-order) ja tilauksesta kokoonpanevat (engl. assemble-to-order) -yritykset voivat tehdä toimitusajasta vahvan kilpailuedun. Kohdeyritys, pohjoismainen korkean teknologian elektroniikkavalmistaja, käyttää valmistuksen vakioläpimenoaikalupauksia (VVL) toimitusaikalupauksiensa perusteena.

Tämä tapaustutkimus pyrkii identifioimaan tuotteet, joiden VVL:t tarvitsevat parantamista, ja antamaan kehitysehdotuksia prosessiin, jossa VVL:t määritetään ja ylläpidetään. Lisäksi tutkimuksen tavoitteena on esittää vaihtoehtoisia malleja toimitusaikalupauksien tekemiseen, analysoida tuotantoympäristön vaikutusta toimitusaikalupauksiin sekä selvittää toimitusajan merkitystä tuotantoyritykselle.

Kirjallisuuskatsaus sekä laaja nykytilatutkimus tehtiin, jotta tavoitteisiin pystyttäisiin vastaamaan. Nykytilatutkimus koostuu teemahaastatteluista, kvantitatiivisesta myyntidata-analyysista sekä lyhyestä vertailuanalyysistä kilpailijoihin. 18 kohdeyrityksen työntekijää haastateltiin ymmärtääkseen VVL-mallin nykytilan vahvuudet ja heikkoudet, sekä selvittääkseen kehitysmahdollisuuksia. Myyntidata-analyysin avulla pystyttiin antamaan dataan perustuvia kehityssuosituksia VVL:ien kehittämiseksi.

Tulokset osoittavat, että kohdeyrityksen toimitusajat ovat yleisesti ottaen kilpailukykyisiä, mutta VVL-malli aiheuttaa tarpeetonta työtä ja on kehitettävissä. Kirjallisuuskatsauksen perusteella lupaava vaihtoehto VVL-mallille voisi olla hankintaketjun resursseihin perustuva kehittynyt toimituslupaus –malli (engl. advanced available-to-promise). Nykytilatutkimuksen perusteella esitetään lista tuotteista, joiden VVL:t tarvitsevat parantamista. Myös kehitysehdotuksia VVL-prosessin kehittämiseksi esitetään. Prosessiin liittyvät parannusehdotukset ovat osoitettu uustuoteprosessiin, jotta VVL-päätökset saataisiin standardoitua ja perustellut päätökset varmistettua. Lisäksi tarjotaan kehitysehdotuksia siihen, kuinka VVL-mallin suoriutumista voitaisiin arvioida ja miten ja milloin VVL:iä tulisi päivittää.

PREFACE

Writing a master's thesis was a great learning experience. I am grateful to the case company for providing me this interesting topic.

I want to thank my instructors both, Suvi and Juhana, at the case company who guided me throughout this process. You both gave me very good and truly inspiring instruction, and always arranged time for my questions, which I appreciate a lot. I also want to express my gratitude to my supervisors at TUT. Especially Minna gave me valuable guidance and good tips for academic writing.

I am grateful for all the employees at the case company who contributed to the work described in this thesis. We had many inspiring discussions.

My friend Outi helped me in proofreading the thesis – big thanks for that!

Last but not least, I want to thank my girlfriend and my family for all the support throughout this project and my studies.

Vantaa, 19. May 2015

Tapani Salminen

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LIST OF SYMBOLS AND ABBREVIATIONS

ATO	Assemble-to-Order production strategy
APS	Advanced Planning and Scheduling
BI	Business Intelligence
B2B	Business-to-Business
B2C	Business-to-Consumer
CCO	Committed Customer Orders
CEN	Controlled Environment
CON	Common Due Date
CODP	Customer Order Decoupling Point
CO2	Carbon Dioxide
CTO	Configure-to-Order
DSCB	Demand and Supply Chain Balancing
DR	Design Review
DTO	Design-to-Order
ERP	Enterprise Resource Planning
ETO	Engineer-to-Order
FMLTP	Fixed Manufacturing Lead Time Promise
HVAC	Heating, Ventilation, and Air Conditioning
IN1	Instrument Manufacturing Team 1
IN2	Instrument Manufacturing Team 2
IN3	Instrument Manufacturing Team 3
JIT	Just-In-Time
LCM	Life Cycle Management
MPS	Master Production Schedule
MTO	Make-to-Order
MTS	Make-to-Stock
OPP	Order Penetration Point
OPS	Operations, case company's operations is responsible for order fulfillment of products to the customers.
OTD	On-Time-Delivery
PDM	Product Data Management
RAN	Random Due Date
RSD	Relative Standard Deviation
R&D	Research and Development
SLK	Slack
SMLTP	Sold Manufacturing Lead Time Promise
VBA	Visual Basic for Applications

n	number of observations
s	standard deviation
$\bar{x}$	arithmetic mean

1. INTRODUCTION

"Fast and reliable customer order promises are increasingly important in today's competitive markets in order to retain customers and gain market share. (Stadtler & Kilger 2008)"

Competition is fierce in today's global markets. Lean manufacturing philosophy has led to inventory optimization and strict and accurate delivery time requirements. This means that delivery time and delivery reliability are some of the key competitive factors for manufacturing firms. Reliable and fast delivery may enable higher price premiums and profits. As Porter (2008) states, companies competing on other dimensions than price – such as product features and quality, support services, delivery time and brand image – are less likely to erode profitability, since these dimensions improve customer value and can support higher prices.

This thesis aims at providing a thorough current state analysis of the case company's customer order promising model and provides concrete improvement suggestions for it. The case company's order promising model is based on predefined fixed manufacturing lead time promises (FMLTP). This model has evolved over time. The current state analysis reveals the advantages and challenges of the FMLTP model. The analysis relies on semi-structured interviews, an extensive sales data analysis and on competitor benchmark. Based on the results of the current state analysis and the literature review improvement suggestions regarding the order promising model are presented.

The literature review discusses delivery time factors affecting delivery time especially from the case company's manufacturing environment point of view. This section analyzes customer order decoupling point (CODP) alternatives and their consequences to delivery time promises as well as consequences of mass customization, importance of delivery time in competition and other possible models for delivery time promising.

The structure of the thesis is as follows. Section 2 outlines the research environment and methodology, whereas Section 3, the literature review, is the theoretical basis of the thesis. Section 4 presents the current state analysis after which Section 5 provides recommendations for the case company. At the end conclusions are drawn. Appendices include the interview questionnaire used, a list of the interviewees and a screenshot of the sales data analysis Excel spreadsheet.

2. RESEARCH ENVIRONMENT AND METHODOLOGY

The purpose of this section is to introduce the research environment and methodology. The section is further divided into six chapters.

The section begins with description of the project background and presenting the case company presentation. The next two chapters discuss research objectives, questions and scope. After that the section proceeds with a brief overview of the previous research on topic. At the end, section presents the research methods and materials.

2.1 Project Background

The case company wants to improve its fixed manufacturing lead time promises (FMLTP). The ordered product and order quantity define the FMLTP. These promises are classified in predefined tiers that are Fast Track (one day), Small Standard (three days), Large Standard (four weeks) and an order specific On Request class for the largest orders. In addition, a pilot Medium Standard (two weeks) classification is recently introduced to one significant product family. Table 1 presents an example of the case company's FMLTPs. For instance, if a customer orders 4 pcs of Product X the manufacturing lead time is 3 days. If the customer wanted 25 pcs of Product X the salesperson would need to check the available the manufacturing lead time from the production planners before promising a certain manufacturing lead time and delivery time for the customer. Likewise, if 6 to 20 pcs are wanted faster than with a 4 week manufacturing lead time, production planning must be consulted.

Table 1. *Example of FMLTPs.*

Product	Small Standard (3 days)	Large Standard (4 weeks)	On Request
Product X	1 - 5 pcs	6 - 20 pcs	21 – pcs
Product Y	1 - 20 pcs	21 - 100 pcs	101 – pcs

The case company has recognized two main problems in its FMLTP model. Firstly, the company has identified a mismatch between the market needs and the current standard FMLTPs. In practice, the case company promises unnecessarily short or long FMLTPs for certain products as compared to the market needs. This mismatch is visible since some products are constantly sold with longer or shorter manufacturing lead times than

they, according to the FMLTPs should. In other words, these FMLTPs differ from the market needs resulting in orders that are sold with order specific manufacturing lead time promises.

Secondly, the process of creating and revising the FMLTPs is unclear and non-standardized. The FMLTPs are defined during R&D (Research and development) project but without proper guidelines.

2.2 Case Company

The case company is a Nordic high tech electronics manufacturer. The company serves customers in over 150 countries and employs over 1600 employees. The organization is divided into two business areas, which are called in this thesis as system business area and industrial instrument business area.

System business is mainly project-based, whereas instrument business is more traditional product business. The company's customer base ranges from numerous small customers to large institutions. This thesis concentrates on the FMLTP process of instrument business area, although the results should be likewise applicable for product sales of system business area.

2.2.1 Case Company's Instrument Business Environment

The instrument products are manufactured in a factory called instrument factory. The annual revenue of the manufactured products in the instrument factory is ca. 80-90 million euros. The case company has an extensive instrument product portfolio that consists of dozens of product families. Most products are mass customized. The annual sales volumes of the products range from some hundreds to thousands, the highest annual sales volume of a single product being over 11 000. The product life cycles are long. Customers might use the products for dozens of years. The manufacturing life cycle is rather long as well as compared to other electronics industries – principally, in consumer electronics such with as mobile phones the life cycles are substantially shorter.

The case company's instrument products are sold to several thousand unique customers yearly. The order sizes range relatively from single unit orders to orders of several hundred units. Majority of orders are small deliveries (i.e. Small Standard) single pcs deliveries. The fewer larger quantity (i.e. Large Standard and On Request), tens to even hundreds of pcs, orders are important as well because they represent a significant proportion of the total annual sales volume.

The competitive advantage of the products is high performance, reliability and quality that is based on excellent technology and product design (Case company 2014a). Other

competitive factors are expert sales and support as well as competitive delivery times for configured products (Case company 2014a). A proverbial customer operates in a challenging environment and requires state-of-art product quality.

The production strategy is assemble-to-order (ATO). ATO means that the assembly begins only once the customer has placed the order. Products are assembled according to customer specifications from a stock of standard and modular components and subassemblies. In general, the market demand for delivery times ranges from short to medium (see Chapter 4). The case company responds to the market demand by means of Lean manufacturing principles including flexible production cells and multi-talented operators.

2.2.2 Case Company's Manufacturing Lead Time Definition

According to Lanz et al. (2013), definitions of performance indicators vary a lot. This applies to the definition of the manufacturing lead time as well. Different companies may have alternative definitions for manufacturing lead time. The difference between the manufacturing lead time and the production lead time can also cause confusion. In addition as no universally standardized and accepted definition exists, the understanding about lead times might also vary because of different personal preferences and work background (Rajaniemi 2012). The case company's definition and the definition for manufacturing lead time used in this thesis is as follows:

Manufacturing lead time is the time interval from sales order booked [visible for production planners] in the Enterprise Resource Planning (ERP) system to production completed [manufacturing due date] (Case company 2012).

Figure 1 clarifies the case company's definition of the manufacturing lead time. In the case company, the most of the manufactured instruments go straight to the packing and shipping after the production is completed.

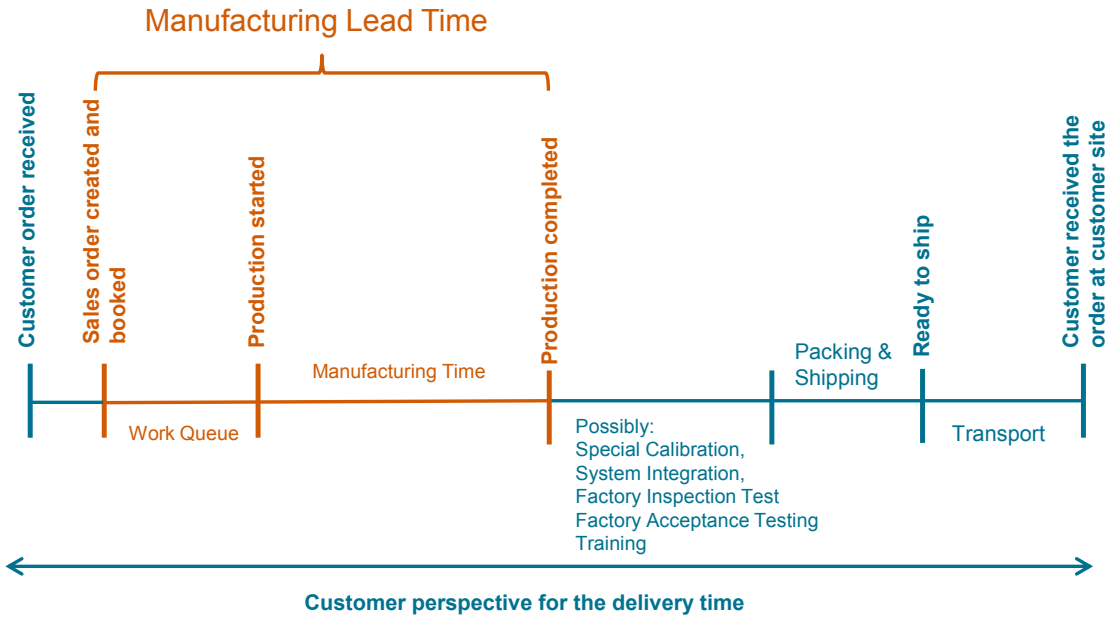

Figure 1. *Manufacturing lead time definition in this thesis.*

This definition appears to be in accordance with the often used definitions in literature. For instance the APICS definition for manufacturing lead time is:

"The total time required to manufacture an item … for make-to-order products, it is the length of time between the release of an order to the production process and shipment to the final customer … included here are order preparation time, queue time, setup time, run time, move time, and put-away time (APICS 2013, p.98)."

On the other hand Hill and Hill (2009, p.81) use the term operations lead time to describe the same thing. They formulate operations lead time to be a combination of material lead time or order backlog (number of accepted orders in work queue), whichever is greater plus the process lead time (time required to make the order).

2.3 Research Objectives and Questions

The target of this thesis is to provide suggestions for improving the case company's current manufacturing and planning process, concerning the FMLTPs. The purpose is not to change the FMLTP model but to explore how the current model could be adjusted to respond the market need better. The four main research objectives listed below clarify the goal and the structure of this thesis:

1) Conduct thorough current state analysis. What are the pros and cons of the case company's current FMLTP model?
2) Identify products with mismatch between the market needs and the current FMLTPs. Propose improvements for the FMLTPs for the identified products.
3) Suggest guidelines for FMLTP creation and revision.

- Clarify how the FMLTPs should be defined in NPI (New Product Introduction) process.
- Define how and when the FMLTPs should be revised as the product is already in the market. Clarify the possible drivers that should trigger the revision of the current FMLTPs.

4) Conduct a literature review according to case company's wishes. The case company wanted a brief academic overview of the topics discussed in the literature review.

Research questions listed below give direction for the literature review and the planning of the current state analysis. In addition to the literature review, the research questions were taken into account as the interview questions were formed.

1) Which important factors, from market and manufacturing environment viewpoints, should be taken into account as FMLTPs are defined and maintained?
2) What are the most common means for delivery time promising in ATO and MTO (Make to Order) industries?
3) What is the importance of delivery times to manufacturing companies?

If the research objectives will be met, the financial benefits are assumed to be achieved by saving the working time of the production planners and salespersons due to fewer lead time expedition requests. The ability to respond the market needs better should result in better customer satisfaction, more competitive offering and also more won orders, increased revenues and possibly higher market share.

2.4 Research Scope and Limitations

The purpose of this chapter is to locate the topic of the thesis in a wider context and to clarify the limitations. Figure 2 illustrates the scope of the thesis within the product sales to delivery process.

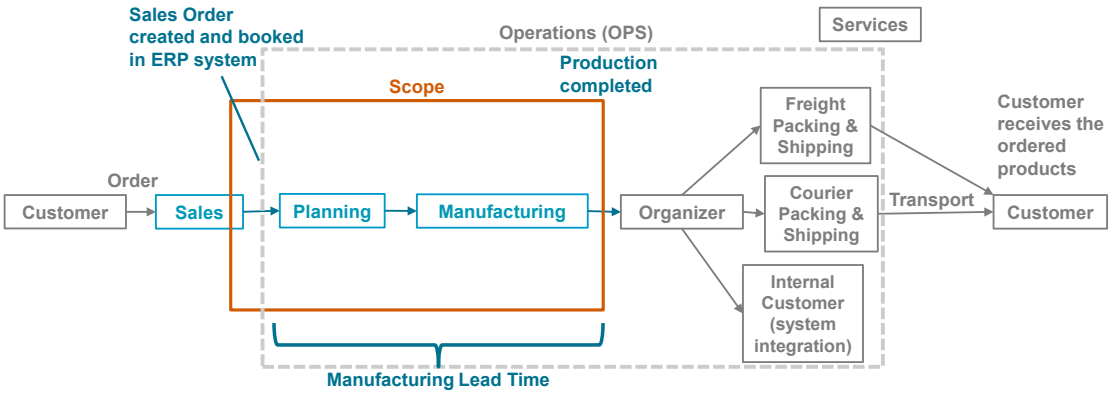

Figure 2. *Simplified product sales to delivery process and the scope of the thesis.*

Out of the scope are

- sales process, except FMLTP selection that is included in the scope;
- delivery process (i.e. organizing, packing & shipping and transport);
- services;
- manufacturing and supply chain improvements planning.

The exclusions, as seen above, were done because it would not be realistic to include all those processes profoundly in a master's thesis project. The FMLTP selection in the sales process includes selecting the appropriate FMLTP, and the possible communication with production planning. Delivery process is excluded as the case company typically uses standard courier services.

The standard courier services refer to services provided by big logistics companies such as UPS and DHL. The courier collects the packed products from the case company's outbound logistics, that is the packing and shipping department, and handles the transportation, which is most often air freight. The courier services are a transparent shipping method. The standard courier shipping services are well-known among customers as the system is widely used in B2B (Business to Business) and B2C (Business to Consumer) markets. Customers know what it means and what to expect as they are told that the delivery time is the FMLTP plus the standard courier shipping time. Alternatively, instruments are sold to internal customer – to system integration. In case of system integration, the orders are typically sold with long manufacturing lead time promises, because orders are known early and booked early into ERP system.

The exclusion of manufacturing and supply chain improvement planning means that, for instance, in case of limited production capability is identified to cause longer delivery times than markets require, this thesis does not cover planning how to resolve the production problem.

2.5 Previous Research on Topic

Surprisingly, research papers that thoroughly discuss the delivery promising model that represents the case company's manufacturing environment and FMLTP model were not found. Some authors mentioned that delivery promises may also be based on fixed lead times but in-depth analysis was not obtainable (see Chapter 3.3). Because the literature did not exist or was very scarce on order promising in such manner as FMLTPs, the importance of the interviews became substantially high. Respectively, the literature on how to assign due dates is limited as compared to the existing literature on scheduling to meet the due dates (Moses et al. 2004).

Nevertheless, as advanced planning and scheduling (APS) has caught the interest of practitioners especially during the last decade, good literature and academic papers re-

ferring to variations of available-to-promise (ATP) systems exist. Likewise, many practitioners have discussed customer order decoupling points (CODP), different manufacturing environments as well as the significance of delivery time in competition against competitors.

For instance, Stadler (2005, 2008), Pibernik (2005) and Chen et. al. (2001) have contributed research on ATP and its variations. From field of CODP among others Olhager (2003, 2010) as well as Rudberg and Wikner (2004) could be mentioned. Silveira et al. (2001) and Fogliatto et al. (2012) have contributed two very thorough literature reviews on mass customization, which is good starting point to the literature on mass customization. There is an abundance of papers about competitive advantages. Some of the main practitioners who have discussed delivery time as one competitive advantage are Stalk (1980), Stalk and Hout 1990, Hill (1993) and Easton and Moodie (1999).

2.6 Research Methods and Materials

Figure 3 depicts the context and choices for choosing research strategy and methods. The research problem setting underlies all the decisions between alternative choices presented in Figure 3 (JYU 2015).

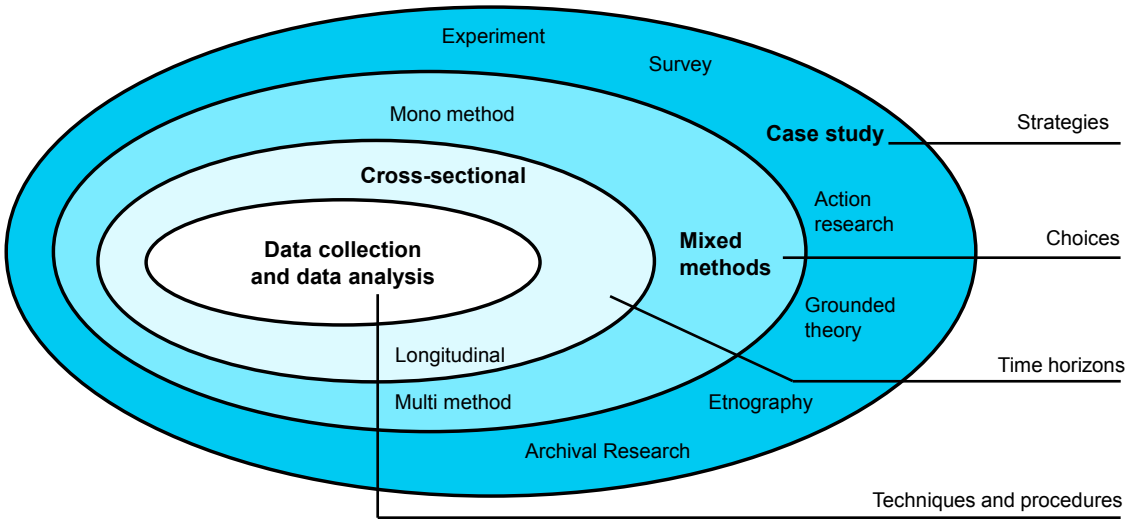

Figure 3. *"Research onion" (adapted from Saunders et al. 2009, p.138).*

The most important aspect in choosing research strategy is that the chosen strategy enables to answer the research problem and meet the objectives (Saunders et al. 2009, p.146). This thesis is a case study. A case study studies a contemporary phenomenon in its real circumstances (Yin 2011, p.17). Shuttleworth (2008) explains that a case study is an in-depth study of a certain situation. The phenomenon, situation, is in this thesis the case company's FMLTP model and its performance. According to Saunders et al. (2009) a case study is most often used in explanatory and exploratory researches. They

continue that a case study often combines variety of data collection methods and add that triangulation is likely to be needed to enhance the reliability of the research.

Cohen et al. (2007, p.141) define triangulation as the use of two or more methods of data collection in the study. This brings us to the next layer of the research onion. This thesis is a mixed method study as it combines both quantitative and qualitative methods. Quantitative is used as a synonym for data collection or data analysis procedures that generate or use numerical data whereas qualitative methods use and analyze non-numerical data (Saunders et al. 2009, p.151).

A longitudinal research studies a change or development of specified object or phenomena over time (Saunders et al. 2009, p.155). Longitudinal study may be conducted also by analyzing or re-analyzing published historical data (JYU 2015). Cross-sectional research studies a particular phenomenon in a particular time (Saunders et al. 2009, p.155). The main interest lies in the current state rather than in change over time (JYU 2015). Thus, this thesis is a cross-sectional study.

The middle part of the research onion is data collection and data analysis techniques and procedures. The consecutive subchapters discuss these aspects.

2.6.1 Selection of the Interview Type

A common typology to categorize interviews is to divide them between

- structured interviews;
- unstructured interviews;
- semi-structured interviews (Saunders et al. 2009, p.320; Jääskeläinen 2014).

Yin (2011) divides interviews into structured and qualitative interviews. In his categorization qualitative interviews cover both semi-structured and unstructured interviews.

Characteristic of structured interviews is that a formal questionnaire is used and all interviewees are asked the same questions in the same order and the answers are often also pre-coded or fixed (Saunders et al. 2009, p.320; Cohen et al. 2007, p.353). Standardized structured interviews are typically used to gather data that will be later the subject of quantitative analysis (Saunders et al. 2009, p.321). The quantitative data needed to this thesis was available in the ERP-system.

Unstructured interviews are informal and conversational by character (Saunders et al. 2009, p.321; Cohen et al. 2007, p.353). Both authors exemplify that questions are not formed in advance but they rather emerge from the context of the conversation. The strength of this type of interview is that the interviewee has the opportunity to talk freely, which may rise issues that would not be addressed in other type of interviews (Saunders et al. 2009, p.321). The weakness is that the collection of data is less system-

atic and is done with different set of questions (Cohen et al. 2007, p.353). Thus, the data organization and analysis may be considerably difficult. In this thesis, the themes of the information needed were identified before the interviews. Hence, unstructured interviews were not seen applicable to this study.

The third, and the interview type used in this thesis, is a semi-structured interview. Semi-structured interviews are based on a list of topics and open-end questions (Saunders et al. 2009, p.320; Cohen et al. 2007, p.353). The interviewer decides the asked questions and their sequence (Cohen et al. 2007, p.353; Yin 2011, p.134). Typically the interviewer poses additional questions (Saunders et al. 2009, pp.320–321). This type of an interview makes the data collection more systematic yet keeping the interview conversational (Cohen et al. 2007, p.353). The potential weakness is that the interviewer's flexibility in wording and sequencing questions can result in different responses and reduce the comparability of the answers (Cohen et al. 2007, p.353).

The set of questions (presented in Appendix A) were sent to the interviewees beforehand to enable the participants to prepare themselves for the interview. To ease the data analysis and to make the collected data more comparable the main questions were asked in a similar order. Even though the order of the questions was fairly rigid, the nature of semi-structured interviews was maintained by allowing the questions to be answered quite freely. Several additional questions were asked to ensure that all the interviewees expressed their opinions and insights in all desired issues.

2.6.2 Quantitative Sales Data Analysis

Quantitative research is based on presenting and interpreting the research object by means of statistics and numbers (JYU 2015). According to Saunders et al. (2009, p.414) quantitative, numerical data need to be processed to convey meaning and make it useful – turn it into information. They continue that this is made by using quantitative techniques as graphs, charts and statistics. Software programs such as IBM SPSS Statistics, Minitab or Microsoft Excel are often used to perform the numerical analysis. (Cohen et al. 2007, p.501).

Sales data analysis represents quantitative research in this thesis. The basic data comes from the case company's ERP system and is processed in Excel. Chapter 4.3 describes in detail the sales data analysis.

3. LITERATURE REVIEW

The purpose of this literature review is to discuss the characteristics and requirements of the business environments in which the case company is positioned in. Existing literature is reviewed in order to deliver theoretical framework and context for the current state analysis and proposed improvements. Secondly, this section answers directly to the research questions to presenting the common means of delivery time promising and discussing the importance of delivery time for manufacturing firms.

This theory section begins with introduction to different manufacturing environments. The next chapter discusses the delivery time's significance as competitive asset. After that, the following chapter looks into different models for delivery time assignment. The latter chapter concentrates on discussing the topic from the point of view of the case company's manufacturing environment.

3.1 Manufacturing Environment

APICS (2013, p.98) defines a manufacturing environment as a framework in which manufacturing strategy is developed and implemented. They continue that the framework consists of elements such as corporate and business unit strategy; manufacturing process and technology decisions; product related decisions such as product mix and product design; and management competencies. Manufacturing environment refers often only to whether the products are make-to-stock, assemble-to-order or make-to-order (APICS 2013, p.98; Nicholas 2010).

Manufacturing environment is not a standardized term. For instance, Rafiei and Rabbani (2011) refer to MTS and MTO productions systems whereas Olhager (2010) uses the term production situations, and Heikkilä and Ketokivi (2009) denote those as production concepts. Nonetheless, Customer order decoupling point (CODP) separates these manufacturing environments. According to Rudberg and Wikner (2004) engineer-to-order (ETO), MTO, ATO and MTS are the most frequently used CODPs. They continue that positioning of CODP relates, in addition, to the possible and suitable level of mass customization. Mass customization strategy is discussed in this theory section since it is the case company's instrument business strategy.

CODP positioning reflects to delivery times and delivery reliability (Vollmann et al. 2005, pp.455–457). Therefore, CODP positioning is relevant also from the viewpoint of the FMLTPs. This chapter begins with a short introduction to CODPs. After that the concept of mass customization is introduced.

3.1.1 Customer Order Decoupling Point

CODP is sometimes referred as the order penetration point (OPP) (Vollmann et al. 2005, p.20; Rafiei & Rabbani 2011; Olhager 2003). The CODP is the point in which the product is linked to a specific customer order (Olhager 2010; APICS 2013, p.117). The CODP is also the last point where inventory is held (Olhager 2010). Downstream from the CODP, towards finished products, decisions are made under certainty as the customer is committed to the order, whereas upstream decisions are driven by forecasts and speculation (Olhager 2003; Rudberg & Wikner 2004). Heikkilä and Ketokivi (2009, pp.126–127) add that the CODP is also the point that divides manufacturing process between push strategy in downstream of the CODP and pull strategy in upstream of the CODP. Figure 4 presents the productivity-flexibility tradeoff that incurs from the CODP positioning in the value added material flow. In addition, Figure 4 locates the four most often used CODPs.

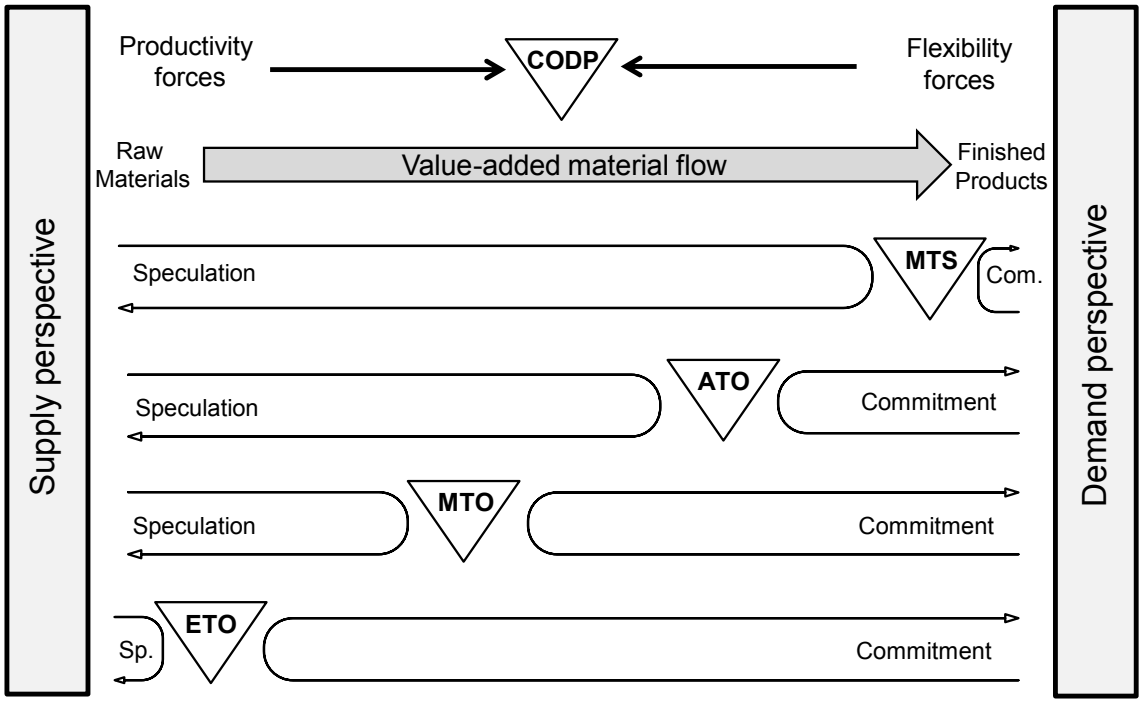

Figure 4. *Productivity-flexibility tradeoff and typical CODP positioning alternatives (adapted from Rudberg & Wikner 2004).*

Value-added material flow is the progressive tasks performed to convert raw materials into finished products. APICS (2013, p.185) defines value-add in terms of manufacturing as the contribution made to final usefulness and value of a product from a customer's perspective in processing raw materials into finished products. Definition value stream is often used in literature to denote the same value added material flow. For instance, according to Womack and Jones (2003, p.353), value stream is "the specific activities that are required to design, order, and provide a specific product, from concept to launch, order to delivery, and raw materials into the hands of customer". Supply per-

spective corresponds to the manufacturer's or supplier's perspective whereas demand perspective equates to the customer's perspective.

The location of CODP affects to the productivity-flexibility tradeoff. The further upstream CODP is, that is closer to raw materials, the more flexibility manufacturer can provide in terms of taking customer specific requirements into consideration (Rudberg & Wikner 2004). Correspondingly, the closer finished products the CODP is, the less flexibility can be accommodated. In the latter situation, instead of flexibility, the importance of productivity is higher. Enhanced productivity may produce cost savings from manufacturer's ability to stabilize production and use efficient line processes (Vollmann et al. 2005, p.457).

In **MTS** manufacturing environment CODP is located to finished products inventory as Figure 4 illustrates. Products are manufactured sales forecast-driven and the customer orders are delivered straight from the finished products inventory (Hill & Hill 2009, p.84). Vollman et al. (2005, p.21) explain that the finished inventory may be located in multiple locations far outside the manufacturing location, which increases the importance of demand tracking and supply chain management. MTS strategy allows manufacturers to concentrate on increasing productivity and efficiency, which leads to price competition in regards bound capital in resources and inventories (Olhager 2003). MTS environment is favorable when sales volumes are high, customers do not require wide product variety and short delivery time is critical (Vollmann et al. 2005, p.457). Examples of typical MTS products are consumer packaged goods, food and beverages, and retail (Kilger & Schneeweiss 2005). Drawbacks of MTS manufacturing environment are holding costs or stock-out costs that occur, firstly, if the market demand fluctuates, and, secondly, since the work-in-process are increased due to more items that are forecast-driven (Rafiei & Rabbani 2011; Olhager 2003). Rafiei and Rabbani (2011) point out also the risk of product obsolescence, which would be a considerable risk for the case company if products were made-to-stock. The case company provides a wide range of configuration options and the demand for certain configuration is hard to predict and volatile, which makes the finished products' inventory obsolescence risk prominent. Tradeoff in MTS environment is between inventory size and service level. Service level in MTS environment, which is usually expressed in percentages, is the proportion of orders picked complete from stock (APICS 2013, p.91).

The next CODP located upstream from MTS is positioned in WIP inventory of parts and components. This is denoted as **ATO** manufacturing environment. According to Heikkilä and Ketokivi (2009, p.113-114) ATO is an example of combination of high production volumes and broad product mix. Typically a company produces numerous kinds of products that are combinations of modules, components and options, which means that the demand is difficult to predict for each end product (Nicholas 2010; Vollmann et al. 2005, p.22). However, as the end products use same the subassemblies and components the aggregated demand for the subassemblies may be predictable and

more stable (Nicholas 2010). Olhager (2010) adds that the volumes of subassemblies are typically sufficiently high, whereas the volumes after CODP are lower due to numerous customized end products. According to Heikkilä and Ketokivi (2009, pp 115-116) flexible ATO manufacturing environment enables relatively fast deliveries of customized customer orders. Delivery promises are built on presumption that the needed material is available at the CODP (Olhager 2010). Some companies that have applied lean manufacturing methods in ATO production have been able to reduce the end assembly time so much that they appear to be MTS companies from the customer's point of view (Vollmann et al. 2005, p.22). For example, cars, computers and mobile phones are typically manufactured in ATO environment (Vollmann et al. 2005, p.22; Heikkilä & Ketokivi 2009, pp.113–116). ATO manufacturing environment is sometimes also referred as configure-to-order (CTO) environment (see e.g. Cheng et al. 2002; Jiao & Helander 2006). Cheng et al. (2002) define that in CTO system the customer can configure the end product by selecting a subset of individual components in any desired combination. Their definition represents the case company's instrument business exactly. The tradeoff in ATO environments is between the amount of variants and costs.

In **MTO** manufacturing environment manufacturing starts only once a customer order is placed (Stevenson 2012, p.682). Materials come from the company's inventory or may be purchased from its suppliers (Vollmann et al. 2005, p.23). If wider customization entered from early phases of production is required, MTO is the appropriate manufacturing environment (Olhager 2003)**.** According to Wei et al. (2010, p.337) MTO is suitable when manufacturing lead time is short and material ready rate is high. Olhager (2003) lists reasons and negative effects of shifting CODP backwards from ATO to MTO. Reasons for are the increased ability to offer product customization, reducing reliance on forecasts, reducing WIP buffers and reducing the risk of inventory obsolescence. On the contrary, backward shifting increases delivery lead times and reduces manufacturing efficiency due to fewer possibilities of optimizing manufacturing process. Airplanes are a good example of MTO production (Taylor 2004, p.29).

According to Gosling and Naim (2009), different researchers agree in the existing literature that CODP is located in **ETO** manufacturing environment at raw materials – and more precisely – at design stage. They continue that researchers, however, disagree on design dimension. Some, as for instance Hill and Hill (2009, p.84), argue that ETO concerns environment where changes to standard products are offered and manufacturing starts only once an order is placed. These authors typically add design-to-order (DTO) manufacturing environment where new products are designed and introduced according to specific customer needs (Hill & Hill 2009, p.84; Gosling & Naim 2009). Others, such as Rudberg and Wikner (2004), consider ETO to cover the above described DTO aspect, a new product being designed and engineered to order. ETO is traditionally associated with complex project environments such as construction and capital goods (Gosling & Naim 2009). A good example is the production of cruise ships.

Olhager (2003) summarizes product, market and production related factors that have an effect on delivery time, production lead time and, thus, also on CODP decision. Table 2 summarizes these factors.

Table 2. *Market, product and production related factors affecting on CODP desicions (Olhager 2003).*

Area	Factor
Market	• **Customer delivery lead time requirements** • **Product demand volatility**: indicates to what extend it is possible to make products to stock or to order • **Product sales volume** • **Product range and customization requirements by customers** • **Customer order size and frequency**
Product	• **Product design**: modular, standard, one-of-kind • **Customization opportunities**: e.g. if customization is wide and entered in early stages in production MTO is necessary • **Materials and material availability** • **Product structure**: deep product structure may indicate long cumulative production lead times
Production	• **Production Lead time** • **Production process flexibility** • **Bottleneck of production**

The case company's instrument business is based on ATO production strategy for the most of the products. Single products are produced to stock along the MTS production strategy.

3.1.2 Mass Customization

Traditionally manufacturers have had to make a choice between low cost products produced with mass production or customized products produced with craft and job shop manufacturing methods (Fogliatto & Da Silveira 2011, p.29). This traditional clear-cut division between cost effective mass production and differentiation based craft manufacturing reflects also Porter's (1980, pp.34–46) famous framework of the three generic competitive strategies: overall cost leadership, differentiation and focus. He states that sticking in the middle, combining cost leadership and differentiation strategy, leads almost guaranteed to low-profitability.

However, mass customization is nowadays an alternative competitive strategy that captures the benefits of both traditional manufacturing methods. Mass customization takes

advantage from the efficiencies of economies of scale in producing subassemblies and components and simultaneously allows the company to provide a wide range of end products due to customer specific end assembly (Heikkilä & Ketokivi 2009, p.127). According to Fogliatto et al. (2012), a very large number of companies have successfully implemented a mass customization strategy. As Blecker and Friedrich (2006, p.2) state, this evidence of successful mass customization implementations reveals that companies can similarly thrive choosing a strategy located in the middle of Porter's (1980) threefold generic competitive strategy framework.

Delayed differentiation, also referred as postponement tactic, is a technique that enables mass customization (Hopp & Spearman 2001, p.344; Stevenson 2012, pp.149–151). Delayed differentiation means that customer specific customization is made as late as possible. The stage, in value added material flow after which customization is made, equals to CODP. Delayed differentiation allows upstream operations to benefit from mass production benefits and simultaneously allows rapid delivery of the orders according to the customer's wishes. Customization might be done as late in the value chain as by customer themselves or by the retailer (Fogliatto et al. 2012).

If the CODP is located at the manufacturing or assembly stage, mass customization requires modular design or product platforms (Mikkola & Skjøtt-Larsen 2004). According to Stevenson (2012, p.150-151), modular design is a form of standardization where single components are grouped into subassemblies. Modularity enables faster end assembly as compared to a situation where all individual components ought to be assembled. Robertson and Ulrich (1998) define product platform as "the collection of assets that are shared by a set of products". They divide the assets into four categories: components; processes; knowledge; people and relationships.

Especially the product platform viewpoint suggests that the success of mass customization depends on market-related and organization related factors. This can be seen in the six mass customization success factors too that Silveira et al. (2001) list in their literature review on mass customization. According to them the six factors are:

1) Customer demand for customization: customers must be willing to accept the longer delivery time and higher cost of the individualized products.
2) Appropriate market conditions: competitors' competitive strategies have to be taken into account in evaluating company's ability to make mass customization a competitive advantage.
3) Company's value chain: the whole value chain from suppliers to retailers must be ready to supply and deliver the customized products.
4) Advanced manufacturing technologies, information technologies and process flexibility technologies are needed.
5) Customizable products: successful mass customized products are modular, versatile and continually renewed.

6) Knowledge must be shared across the whole value chain.

Silveira et al. (2001) highlight that the list above confirms that mass customization is not the right strategy for every company. They continue that the mass customization implementation is complex and requires many aspects to be taken into account including the whole value chain and customers, information technologies and organization structure. Table 3 summarizes the benefits and challenges of mass customization (Blecker & Friedrich 2007).

Table 3. *Benefits and challenges of mass customization according to Blecker and Friedrich (2007).*

Benefits	Challenges
Disappeared end product inventory: no bound capital in storing high value-added end products and no risk of obsolescence of end product inventory.	Delivery times and keeping the promised delivery time is more critical competitive factor when products are made-to-order than in MTS environment where products are not associated with specific orders. E.g. rework has direct impact on ability to deliver the order on time.
Closer match with customer requirements and products.	Product selection may be overwhelming and difficult from customer's perspective.
Price reduction to customer: customer pays only for features he needs	Production variety reduces economies of scale: mass customized products are more cost intensive.
Possibly improved image of company among customers	Overheads are difficult to assign to single product variants. Traditional accounting methods may distort product profitability calculations: cross-subsidization of low volume products through high volume products and assignment of higher than true costs to high volume variants.
Closer collaboration with customer, which enables manufacturer to capture information about market trends better than MTS producers.	Increased complexity in the manufacturing system: increased number of components and parts, more suppliers, high diversity of production processes on the shop floor, production planning and scheduling is challenging, production cycle times may be longer.

3.2 Delivery Time as a Competitive Asset

Managing and shortening lead times in NPI projects, production, sales and distribution is a powerful competitive advantage (Stalk 1988). Stalk and Hout (1990, pp.1–4) revealed the significance of responsiveness and short delivery times. They stated that companies with significantly shorter delivery times than their competitors grow at least

three times faster than the competitors and have at least doubled the profitability of industry average. Also later publications suggest that delivery time tend to offer strong competitive advantage (see e.g. Lödding 2013, pp.20–24; Easton & Moodie 1999). This subchapter concentrates on the significance of the delivery time as competitive asset.

Practitioners have traditionally identified four competitive priorities in operations management, which are price, quality, delivery time and flexibility (e.g. Ward et al. 1998; Easton & Moodie 1999; Sarmiento et al. 2007). In addition, services are often mentioned as the fifth competitive base (e.g. Heikkilä & Ketokivi 2009, p.55; Hill & Hill 2009, p.49; Handfield & Pannesi 1992).

As stated in Chapter 3.1, delivery time is a more critical competitive factor for MTO and ATO manufacturers than to MTS manufacturers. Delivery time may differ significantly across MTO and ATO firms, whereas delivery time of MTS firms depends primarily on the location of the end product inventory. Hence, it is unlikely for a MTS manufacturer to make delivery time a differentiating competitive advantage. In addition to end inventory location decisions, MTS manufacturers must optimize inventory level regarding trade-off between the service level and the cost of inventory. Easton and Moodie (1999) add that if the MTO company's capability to offer short delivery time is based on shortened production and material lead times, it enables lower WIP and raw material inventories, which leads to cost reductions and improved cash flow that eventually results in higher profits.

The importance of the delivery time depends, naturally, on the customer need. Christensen and Raynor (2003, pp.126–131) discuss this from the product's functionality and reliability perspective. Their point is that a situation when functionality and reliability of the product is not yet good enough to match with customer requirements differs from a situation when customer requirements are exceeded in terms of product quality. Figure 5 illustrates that.

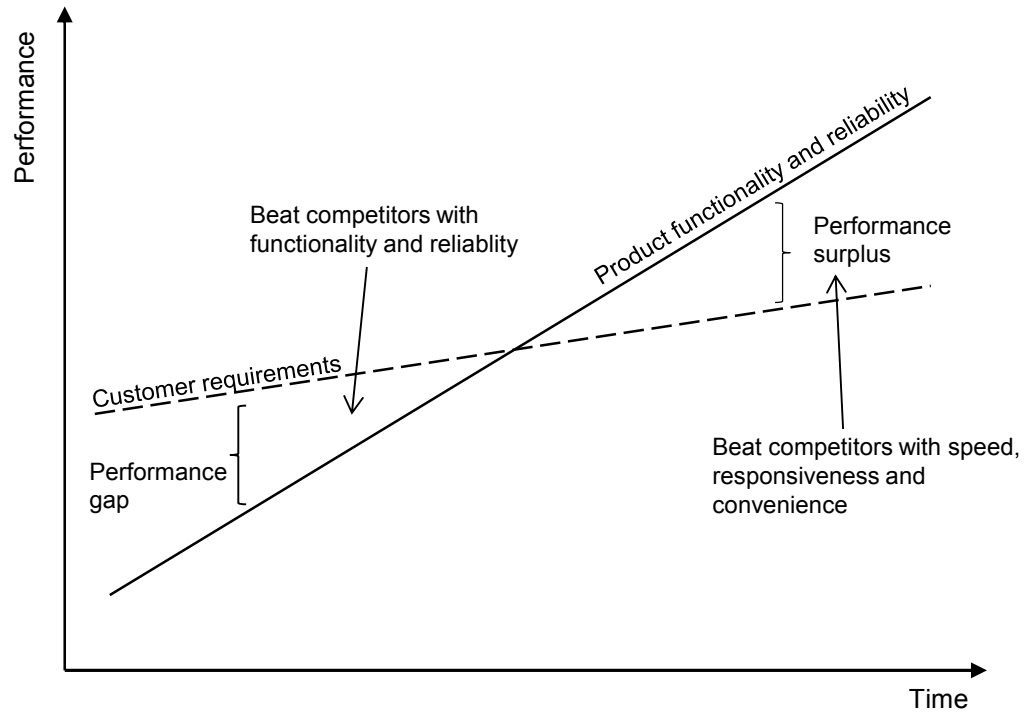

Figure 5. *Product performance vs. customer need (adapted from Christensen & Raynor 2003, pp 127).*

The dashed line represents customer need. The requirements rise gradually over time. Performance gap means that products available in the markets fail to meet the customer requirements. Competitive edge derives from the ability to make better product than competitors even though customer need is not completely addressed with product performance.

Hill (1993) formulates a theory of order qualifiers and winners that fits to Christensen's and Raynor's idea. According to Hill, order qualifiers are factors and customer requirements for product that have to be met and provided to get the opportunity to compete selling the product to a customer. On the other hand, order winners are product features and other factors that beat competitors and are determinant as customer decides which product to purchase. According to Hill and Hill (2009, p.41), typical order qualifying and winning factors are price, quality, delivery speed and reliability, design, product variety, brand, technical support and after-sales support.

As can be seen on the left side of Figure 5, when customer requirements are not yet met, product functionality and reliability are order winning factors. The company that provides the best product in such terms is likely to win the order (Christensen & Raynor 2003, pp.128–130). As illustrated on the right side of the Figure 5, when the product functionality and reliability exceeds the customer requirements order qualifying factors are the customer requirements. All companies that exceed customer requirements compete of the customer order. In this situation firms must identify what are the order winning factors that close the deal (Hill & Hill 2009, p.48). According to Christensen and

Raynor (2003, pp.130–132), the order winners are speed, responsiveness and convenience. They continue that the same order winners, factors which a firm does better than the other firms, guarantee price premium over competitors. Porter (2008) complements that the other competitive dimensions than price – product features, delivery time and brand – can improve the customer's experienced value against competitors' substitute products creating a moat between new market entrants.

Short delivery time is not enough. In addition to delivery speed, delivery reliability is highly important in MTO and ATO manufacturing environments (Handfield & Pannesi 1992; Easton & Moodie 1999). Delivery reliability equals to firms ability to deliver the product on or before the promised due date, which is often referred to as OTD (On Time Delivery) (Handfield & Pannesi 1992). On the other hand, Kaplan and Norton (1996) add that companies operating under a JIT (Just-In-Time) discipline with zero inventories do not accept early deliveries but instead insist very accurate deliveries. They exemplify that, for example, Japanese car manufacturers Honda and Toyota require deliveries from their suppliers within strict 1-hour timeframe. They continue that when JIT is deeply integrated such as at Honda and Toyota, a late delivery would cause the production process to stop, because of operating under zero inventories. Respectively early delivery is not possible, because these companies do not have inventories to store early deliveries. APICS (2013) defines OTD as a percentage of receipts delivered on time. According to Kaplan and Norton OTD should be measured against customer expectation. Easton and Moodie (1999) suggest that poor OTD exposes company to a risk of diminished future business prospects and to a risk of penalties for tardy deliveries.

Handfield and Pannesi (1992) present a simple framework to illustrate a company's delivery performance. They argue that delivery performance can be one of the four combinations of delivery speed and delivery reliability as presented in Figure 6.

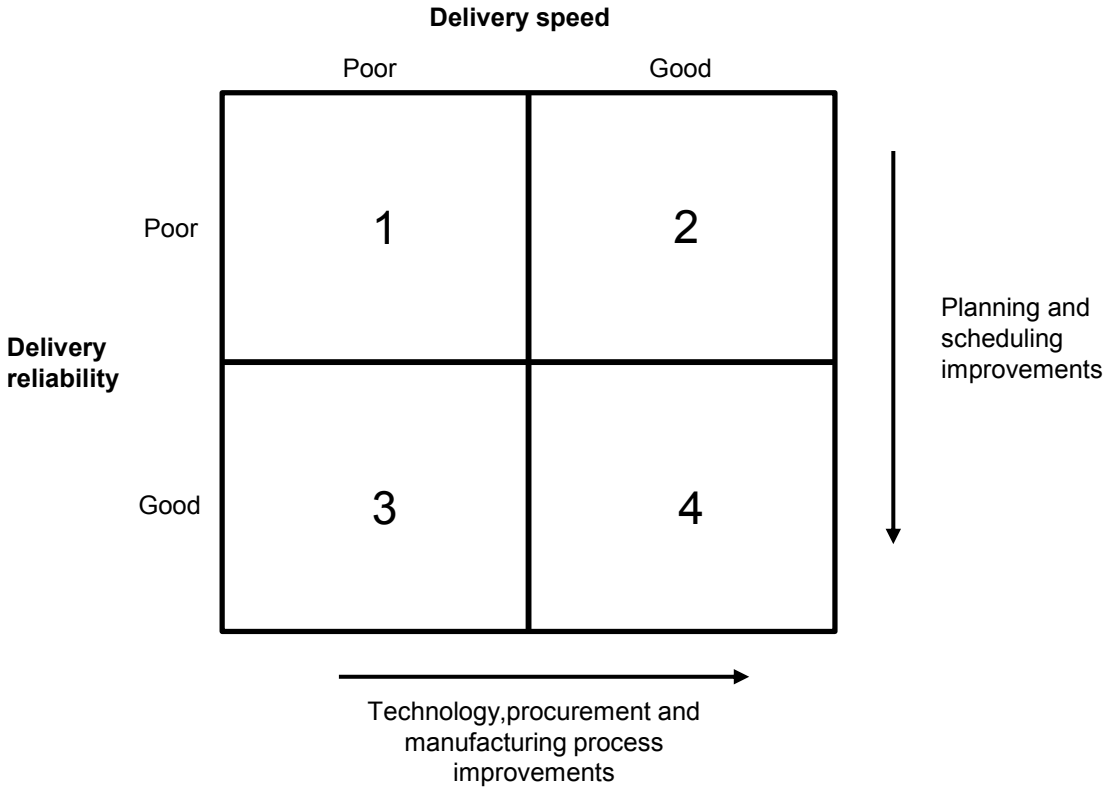

Figure 6. *Fourfold table of delivery speed and reliability (adapted from Handfield & Pannesi 1992).*

In the first quadrant both the company's delivery speed and its delivery reliability is poor. The company is likely to be in a serious trouble, except the market is such that these factors are not order winners. In the quadrant 2 the company's delivery speed is good but the reliability is poor. The company in the quadrant 3 has long delivery times but its OTD is good. This indicates that the company's delivery promises are far in the future. The ideal state is of course the quadrant 4, where the company has good, short delivery times and concurrently a very good OTD performance. The trade-off between delivery reliability and delivery speed is challenging to manage. For instance, the company may try to convince customers to accept longer delivery times and hence improve the OTD figures. Nonetheless, this may lead to customer dissatisfaction and "mysteriously" lost business. (Handfield & Pannesi 1992)

Handfield and Pannesi (1992) highlight that improvements in delivery reliability can be done improving planning and scheduling whereas the only way to improve delivery times for MTO companies is to reduce lead times. Chapter 3.1 discussed the benefits and challenges decreasing delivery times in moving CODP downstream toward the customer.

3.3 Different Models for Delivery Time Promising

Realistic delivery time promising creates customer trust and loyalty. Customers prefer realistic delivery promises, even if they are longer than requested, to inaccurate and unrealistic promises (Hamilton 2002). Vollman et al. (2005, p.179) state that accurate delivery time promises allow companies to operate with lower inventory levels. They continue that these companies manage the delivery times rather than have safety stocks to respond to uneven demand.

Delivery time promises may be based on one or a combination of the following factors (Kouri 2014):

1) Available finished products inventory (also e.g. Stadtler 2005)
2) Master production schedule, MPS (also e.g. Stevenson 2012, pp.494–499)
3) Available capacity (also e.g. Dickersbach 2006)
4) Material availability (also e.g. Moses et al. 2004)
5) Fixed lead time (also e.g. Easton & Moodie 1999)
6) Project plan

A conventional ATP method incorporates finished products inventory and MPS, whereas advanced ATP (AATP), takes available capacity and materials into account. ATP and AATP are normally integrated in the ERP and Advanced Planning Systems (Pibernik 2005). Delivery times may be promised also according to fixed lead times. The case company's FMLTP model represents this approach. Kouri (2014) notes that fixed lead times can be adjusted according to order backlog and capacity. Project plan is used for example in ETO manufacturing environment where companies are commited to delivery dates defined in the project plan. Project plan-based delivery promising is excluded from this theory section, because it does not represent the case company's business environment.

All of the methods listed above aim at providing the due dates to the customer promptly. Framinan and Leisten (2010) state that the today's trend and competitive environment, especially e-business, requires companies to automate their order capture process and to provide quotes even in real-time. Order capture process includes responding to a customer's request about at which dates and prices the required products may be delivered (Kingsman et al. 1996; Framinan & Leisten 2010).

Cheng and Gupta (1989) explain that in job shop production each order is assigned a due date for delivery before it is released to shop floor for processing. Academic researchers have provided many theoretical methods for delivery date promising. Practitioners have divided delivery date promising, a.k.a. due date assignment methods typically into two types: exogenous and endogenous (see e.g. Cheng & Gupta 1989; Park et al. 1999). Figure 7 illustrates this classification.

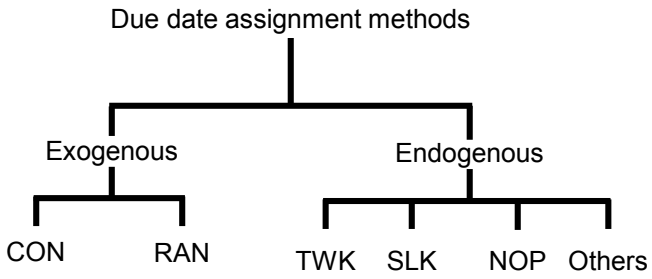

Figure 7. *Due date assignment methods (adapted from Cheng & Gupta 1989).*

Exogenous, external methods are methods that are not integrated in the production planning procedure (Cheng & Gupta 1989; Corti et al. 2005). Two methods are often referred to within exogenous methods:

1. Constant, a.k.a. common due date, (CON) procedure: all orders receive the same fixed lead time (Cheng & Gupta 1989; Park et al. 1999). This fixed value is usually fixed by commercial function of the company (Corti et al. 2005).
2. Random (RAN): the lead time is random by nature and derives from customer request although it is usually subject to negotiation before acceptance by company (Park et al. 1999).

The case company's FMLTP model is to some extent a combination of CON and RAN methods. As long as predefined FMLTP classes cover the requested order quantity, salespersons assign the predetermined standard lead time to the sales order, which represents the CON method. In case of the requested quantity exceeds the Large Standard upper bound, lead time is subject to negotiation, which is characteristic of the RAN method. Likewise, if the customer is not satisfied with the case company's standard lead times, order specific lead time may be negotiated. Easton and Moodie (1999) argue that most MTO firms use CON lead time procedure which means that they quote the same lead time for every job. They add that actual lead time depends on work content and manufacturing firm's sequencing and scheduling decisions.

Endogenous, internal methods involve production planning in due date assignment. The established due date is based on an accurate estimate of the current throughput time that takes job floor status, current orders and potential orders into account (Park et al. 1999; Cheng & Gupta 1989; Corti et al. 2005). Cheng and Gupta (1989) mention the following methods:

1. Total work content, TWK: due dates are based on current total work content
2. Slack, SLK: given flow allowances, due dates, reflect equal waiting times or equal slacks
3. Number of operations performed, NOP: Number of operations performed on the job define the promised due date.

Many other endogenous methods for assigning due dates exist as well. For instance, Park et al. (1999) and Gordon et al. (2002) introduce several respective methods. The papers discussing due date assignment usually contribute some application of some of the endogenous methods and present a mathematical algorithm to utilize it in a certain situation. Traditionally these papers discuss a single machine context but more recent works have provided models that try to reflect a multi-machine, dynamic and more random real shop floor (Corti et al. 2005). These dynamic approaches often use stochastic approaches to cope with uncertainty caused by uncertain fluctuating demand products environment (Corti et al. 2005). Even though practitioners have developed various due date assignment methods they remain a compromise between accuracy and simplicity (Park et al. 1999; Corti et al. 2005). In addition, the solutions proposed by practitioners are typically stand-alone solutions and, for instance, ERP integration remains usually undiscussed.

In conclusion, the endogenous methods discussed by academic practitioners seem to have too many simplifications or tend to go too complex to maintain in practice, if implemented to the case company's very versatile business environment. The case company's customer orders are hard to predict, product routings are not constant and capacity is not constant, just to mention some obstacles. Suitable solutions may be ATP or AATP solutions that would be integrated in the case company's ERP system. These solutions are presented next.

3.3.1 Conventional Available-to-Promise

APICS (2013, p.10) defines ATP as "the uncommitted portion of a company's inventory and planned production maintained in the master schedule to support customer order promising". This is the conventional definition of ATP. Conventional ATP is always based on finished goods inventory, and it monitors the availability of uncommitted products currently, and in the future, in the finished goods inventory (Pibernik 2005). Hence, conventional ATP is suitable only for MTS manufacturers. This means that because the case company's manufacturing environment is ATO and the case company does not have a finished product inventory, the conventional ATP is not a suitable order promising mechanism for the case company.

However, because the basic logic behind AATP is similar to ATP, an example of ATP calculations is presented. Table 4 clarifies the ATP calculation.

Table 4. *Conventional ATP calculation example (adapted from Stevenson 2012, pp.496–499).*

beginning inventory: 64

	Week				
	1	**2**	**3**	**4**	**5**
Forecast	30	30	30	30	40
Committed customer orders (CCO)	33	20	10	4	2
Projected on-hand inventory	31	1	41	11	41
MPS			70		70
ATP	**11**		**56**		**68**

The pieces of information required for ATP calculations are: beginning inventory, sales forecast, committed customer orders and MPS. First step is to calculate the projected on-hand inventories. The projected on hand inventory is calculated with formula 1.

$$Projected\ on\text{-}hand\ inventory = \\ inventory\ from\ previous\ week - greater\ of\ forecast\ or\ CCOs + MPS \qquad (1)$$

Thus, the projected on-hand inventory for the first week is 64 – 33 + 0 = 31. For week 2 the projected on-hand inventory is 31 – 30 + 0 = 1. For week 3 the result is 1 – 30 + 70 = 41 and so on. Projected on-hand inventory is also used to slate the MPS. The production is scheduled so that the projected on-hand inventory won't get negative (Stevenson 2012, p.497). In this example the projected on-hand inventory would have been negative in weeks 3 and 5. Thus, MPS is scheduled for those weeks. MPS in this example bases in batch production**.** However, ATP can be calculated for leveled production likewise.

Then, ATP can be calculated. There are several slightly different methods for calculating ATP but one often used method is to involve a so-called look-ahead procedure (Stevenson 2012, pp.497–499; Vollmann et al. 2005, pp.176–178; APICS 2013). The idea of a look-ahead procedure is that the projected on hand inventory has to cover all existing orders until MPS is scheduled again (Vollmann et al. 2005, p.177). ATP with look-ahead is calculated with formula 2.

$$ATP\ (with\ look\text{-}ahead) = \\ MPS - CCOs\ until\ a\ week\ (but\ not\ including)\ MPS\ is\ scheduled\ next\ time \qquad (2)$$

In this example MPS is scheduled first time for week 3. Thus, as CCOs from weeks 1 and 2 are summed 53 is obtained as ATP. ATP calculation differs slightly for the first week as beginning inventory is summed with MPS. Thus, ATP for first week is 64 + 0 –

53 = 11, which means that 11 products are available to be sold either in week 1 or week 2.

Subsequent weeks are calculated according to Formula 2. ATP for week 3 is 70 – (10 + 4) = 56 meaning that these 56 products may be sold for week 3 or 4. MPS is scheduled again for week 5. ATP for week 5 is then 70 – 2 = 68.

3.3.2 Advanced Available-to-Promise

As conventional ATP solely monitors the availability of products in finished goods inventory, AATP is a more holistic order execution mechanism. According to generally accepted common definition of AATP, AATP refers to a variety of methods and tools that enhance the order promising responsiveness and order fulfillment reliability (see e.g. Pibernik 2005; Alemany et al. 2013). Chen et al. (2001) give a more detailed, often used description of AATP. According to them AATP "allocates and reallocates available resources, including raw materials, work-in-process, finished goods and distribution capacities, to commit customer order request over time". AATP or specific functions of AATP are sometimes labelled as CTP (APICS 2013, p.21; Stadtler 2005; Kilger & Schneeweiss 2005).

According to ERP system provider Oracle (2015), CTP extends ATP by considering capacity information. Oracle (2015) notes that CTP takes the availability of both materials and capacity into account and thus gives more realistic information than conventional ATP to support delivery time promising.

Kilger and Schneeweiss (2005) list three major reasons for using sophisticated order promising procedures such as AATP:

1) improved OTD enabled by more reliable order quotes,
2) reduced number of missed business opportunities, because of more effective order promising methods and
3) increased revenues and profitability, because average sales prices may be increased.

The first point on the list is obvious. The second point indicates that AATP methods may substantially reduce the time wasted in order quoting, which may be a competitive advantage. Chapter 3.2 stated that speed, responsiveness and reliability guarantee price premiums, which supports the third statement.

Pibernik (2005) classifies AATP systems according to availability level, operating mode and type of interaction with manufacturing resource planning. The suitable AATP method depends on manufacturer's business and manufacturing environment.

Availability level refers to the choice whether quantity and due date promising are based on finished goods inventory or supply chain resources. Supply chain resources include raw materials, WIP, finished products and even production and distribution capacities (Chen et al. 2001).

As stated earlier conventional ATP is always based on finished goods inventory and retrieves the availability of requested products. AATP based on finished goods inventory, however, is a decision making mechanism that allocates finished goods inventory to customer orders and concludes due date promising (Pibernik 2005). This method is naturally applicable only to MTS manufacturers who maintain finished goods inventory.

Instead of finished goods based AATP, AATP based on supply chain resources is applicable to ATO and MTO manufacturers such as for the case company. AATP based on supply chain resources is a systematic resource allocation process, which allocates the available supply chain resources to customer orders and provides due date quotes (Chen et al. 2001; Pibernik 2005). According to Pibernik (2005), pre-condition to successful implementation is detailed information on supply chain resources for each product included in AATP calculations. He clarifies that bill of material, routing plan, as well as manufacturing and distribution capacity requirements are needed to perform resource allocation, AATP calculations.

The second choice is between real time and batch operating mode. Real-time AATP means that commitment to quantity and due date are done at the time of customer requests (Chen et al. 2001). Real-time mode is sometimes referred to as single-order processing (Alemany et al. 2013). With batch-mode AATP potential customer orders are collected together and then, e.g. at the end of the day or week, processed by a model or algorithm that determines the order quantities and due dates (Pibernik 2005). Chen et al. add that (2001) typical e-business order fulfillment systems operate in batch based AATP. They exemplify that initial delivery time promise is made real time, but the final order commitment is carried out by executing batch based ATP. Operating mode has an effect on customer response times and thus on the customer's perspective of service provided by the company, which naturally affects to the models and algorithms used for order promising as well (Pibernik 2005). Alemany et al. (2013) argue that sometimes customers expect immediate answer for their order queries. In these situations batch mode AATP is not possible and each single order has to be processed in real time. They add, however, that real time mode might imply the risk of promising scarce availabilities to wrong customers, e.g. to less important or less profitable customers, in a shortage situation when demand is higher than company's capability to promise. They mention that solution would be allocation planning.

Allocation planning means reserving quotas from ATP to important customers and promising orders according to these quotas (Alemany et al. 2013; Kilger & Schneeweiss 2005). Kilger and Schneeweiss (2005) state that human production planners must con-

trol and adjust the quotas regularly. They continue that the allocation can be exploited to increase the revenues and profitability by allocating ATP to customers who are willing to pay premium prices instead of serving customers on a first-come-first-served basis. ATP without allocation planning would oblige a company to break commitments to other customers in order to quote an order of a more important customer, which has obviously negative impact on OTD and customer satisfaction of the other customers (Kilger & Schneeweiss 2005).

The third and the last choice is between active and passive interaction with manufacturing resource planning. Passive AATP has no direct impact on manufacturing resource planning apart from determining accepted orders and due date promising whereas active AATP is integrated into manufacturing resource system (Pibernik 2005; Kilger & Schneeweiss 2005). Pibernik (2005) exemplifies that passive AATP receives information about finished goods and supply chain resources from manufacturing resource planning. Then, based on that information, order quantities and due dates are quoted. He continues that active AATP generates and modifies the master schedule whilst executing usual order quantity and due date quoting. Pibernik (2005) concludes that active AATP is especially applicable to MTO manufacturing environment, whereas passive AATP suits better to MTS manufacturing environment. He elaborates that active AATP is limited to single unit or small batch production, because it opposes the principles of high and leveled capacity utilization pursued in mass production.

Table 5 summarizes the possible combinations and choices for AATP system. The options that suit best to case company's business and manufacturing environment are typed in orange.

Table 5. *Generic types of AATP (adapted from Pibernik 2005).*

		Availability level			
		Finished goods (FG)		***Supply chain resources (SCR)***	
Operating mode	**Real-time (RT)**	RT/FG/A	RT/FG/P	**RT/SCR/A**	RT/SCR/P
	Batch (B)	B/FG/A	B/FG/P	B/SCR/A	B/SCR/P
		Active (A)	***Passive (P)***	***Active (A)***	***Passive (P)***
		Interaction with manufacturing resource planning			

Since the case company's manufacturing environment is ATO, the suitable AATP systems is based on supply chain resources and is in active interaction with manufacturing resource planning system. The operating mode could be either real time or batch. According to the interviews (see Chapter 4.2), the case company has certain customer and product segments where customers require prompt quotes and deliveries. This indicates

that case company should opt for a RT/SCR/A solution – a real time, supply chain resources availability based solution, which is in active interaction with manufacturing resource planning system.

In addition, three extra functionalities can be added to any of AATP solutions introduced in Figure 6: AATP with substitute products; multi-location AATP and AATP with partial delivery. These strategies are mainly applicable in case of shortage in supply chain resources or finished products inventory. (Pibernik 2005)

AATP with substitute products refers to the possibility to deliver substitute products instead of the product originally ordered by a customer. This requires of course that the customer is willing to accept the substitute product. The substitute product must have at least the same functionality and utility as the initially ordered product. (Pibernik 2005)

Multi-location AATP implies the possibility to fulfill the customer order from a different location. That means that in case a certain location delivers the order on time, AATP planning mechanism checks whether the order could be fulfilled with finished goods or resources sourced at other locations. It is important that multi-location AATP takes different manufacturing and transportation lead times and costs into account. (Pibernik 2005)

AATP with partial delivery refers to the possibility to split orders if the whole required order is not possible to deliver as requested. This means that the order is fulfilled with two or more partial deliveries so that the first part of the delivery is carried out within the requested time window. Similarly as in AATP with substitute products, the precondition is that the customer accepts partial deliveries. If the customer accepts the partial deliveries, AATP determines delivery dates for each partial delivery. (Pibernik 2005)

AATP with substitute products approach is unlikely to be appropriate to the case company as the customers typically require a certain configuration of the product. Likewise, multi-location AATP is not probably necessary to the case company, because it has almost all production in one factory. AATP with partial deliveries would definitely be a suitable feature if the case company decided to have AATP as their order promising system. According to the interviews and discussions with the case company's employees, partial deliveries are sometimes already provided.

Successful AATP implementation requires quality data. Operations and inventory management has to provide relevant and accurate data for the AATP algorithms. Detailed information about supply chain resources is needed. Hence for supply chain resources based AATP, at least the following information is needed for every product (Pibernik 2005):

- bill of material
- routing plan
- manufacturing and distribution capacities for resource allocation
- inventory on-hand and
- supply chain resource availability.

Pibernik (2005) concludes that AATP performance strongly depends on the operation' and inventory management's capability to fulfill the orders promised by AATP. Even the most sophisticated AATP model won't work, if production and inventory management is unreliable.

4. CURRENT STATE ANALYSIS

The objective of the current state analysis is to clarify how the case company's current FMLTP model performs against market requirements and what are the pros and cons of the FMLTP model. The analysis is divided into three sections: interviews, sales data analysis and competitor benchmark.

Conduct of a series of interviews commenced the current state analysis. A partially concurrently performed sales data analysis complemented the interviews. A benchmark analysis of the case company's delivery times against the main competitors concludes this section.

4.1 Conducting Semi-structured Interviews

The purpose of the interviews was firstly to gather information about how the case company's FMLTPs align with market needs. Consequently, the aim was to collect concrete examples of the products or product families whose FMLTPs do not match with the customer needs. The second objective was to obtain understanding on how the current decisions of the FMLTPs are justified and what is the process behind these decisions. Lastly, the views and opinions about, what are the most important factors to consider when making FMLTP decisions, and how the FMLTP process should be developed were gathered.

After defining the above mentioned objectives the questions were formed. Questions were based on the objectives and prior informal discussions about the topic of this thesis with the Head of Instrument Factory and the Head of Purchasing and Planning. Appendix A presents the interview questionnaire. The interview situation advanced always with the following procedure:

1) Short introduction to the thesis scope and the objectives
2) Explanation of the objectives of the interview
3) Warm up questions (Question 1, Appendix A)
4) Main questions (Questions 2-10, Appendix A)
5) Closing questions (Question 11, Appendix A)

As the customer base consists of several thousand customers it would have been extremely time consuming to interview a representative sampling of customers within this project. Hence, the sampling of the interviewees had emphasis on persons who are in constant interaction with customers. Sales Managers and Product Managers were identi-

fied to be the key stakeholders. Salespersons are in constant contact with customers. Regional Sales Manager from every region was interviewed to get understanding of presumable differing market needs in different regions. Regions are China, Europe, Finland, Japan and North America. The Sales Manager who is responsible for global distributor sales was included as well in the interview group of Regional Sales Managers. Like Regional Sales Managers, Product Managers are in frequent contact with customers. Moreover, Product Managers have acted as key persons in making the current FMLTP decisions. Product Managers who are responsible for instrument products were interviewed. In addition, the Business Segment Directors, who have the business (profit-loss) responsibility; Head of Instrument Factory; Instrument Product Production Planner and LCM (Life Cycle Management) Manager were interviewed. A list of the interviewees is presented in Table 6.

Table 6. *List of interviewees.*

Interviewee's position	Number of interviewees (in total 18)
Regional Sales Manager (incl. Global Distributor Sales Manager)	6
Product Managers	7
Segment Directors	2
Head of Instrument Factory	1
Production Planner	1
LCM Manager	1

4.1.1 Documentation and Transcription of Interviews

Each participant was interviewed separately in person. The interviews were face-to-face interviews except the Lync-interviews with the colleagues who work in the case company's locations outside Finland. Each interview was audio-recorded with the interviewee's permission. The audio-recordings enabled writing more detailed transcripts and listening to the replies several times, which makes the analysis more reliable. Pen and paper notes were taken during the interviews. The notes were transcribed to MS Word form right after each interview. Then the audio-recordings were listened to for several times and the detailed transcripts were written afterwards.

Transcribing the audio-recordings is a very time consuming process. When transcribing exactly what was said and possibly even giving indications of the tone of the replies, it takes typically between six to ten hours to transcribe every hour of an audio-recording (Saunders et al. 2009, p.485). Because the interviews were a complimentary data gathering method beside the sales data analysis and benchmarking, it was considered unreasonable to transcribe the interviews in extreme detail. Furthermore, since the objectives of the interviews were clearly defined, the desired themes of the answers were known prior the interviews, which helped to concentrate on the relevant answers. Thus, the methods to reduce the amount of time consumed in transcribing process were scrutinized.

The least time consuming alternative presented by Saunders et al. (2009, pp.485–486) is to transcribe only those sections of each audio-recording that are pertinent to the research. This method was adapted. Audio-recordings were transcribed in such a manner that the most relevant answers were written exactly how they were said and others were summarized using bullet points. Time indicators, minutes:seconds such as 09:28 were typed into the transcripts to help getting back to answers and being able listen to the answer again if needed. Only a few answers that were clearly completely off-topic were left non-transcribed. By following this method the time consumed to transcribe one hour of audio-recording was reduced to approximately between 2.5 to 5 hours.

4.1.2 Affinity Diagram for Data Interpretation

The gathered data from the interviews are audio-recordings converted to written interview transcripts, which is qualitative data. According to Saunders et al. (2009, p.480), distinctive to qualitative data is that they are non-numeric data or data that have not been quantified. Many methods exist for analyzing qualitative data that typically include following the processes: summarizing the gathered data; categorization the data; restructuring the data using narrative (Saunders et al. 2009, pp.482–490). Also Yin (2011) suggests similar kind of manner for analyzing qualitative data the phases being: compiling; disassembling and reassembling; interpreting and concluding.

In this thesis the qualitative data from the interviews were analyzed adapting a method called Affinity diagram (Koskinen 2011). The Affinity diagram method follows the structure presented by Saunders (2009) and Yin (2011). The idea of Affinity diagrams is to visualize observations, cluster similar observations into groups, name the groups, and identify the development opportunities (Koskinen 2011, p.79; Ideo 2011, pp.94–103).

The Affinity diagram was applied along with the following steps:

1) Highlight the interview transcripts: the interview transcripts were printed out and relevant answers highlighted.

2) Display the highlights: the highlighted opinions were summarized in individual post-it notes and spread out to enhance visibility.
3) Identify similarities: the post-it notes opinions were clustered together according to recurring themes.
4) Name the clusters: descriptive names were given to the clusters.
5) Identify development opportunities: the answers in each of the clusters were compared to each other. Key development opportunities were identified and conclusions of the themes in each of the clusters were drawn.
6) Draw conclusions: the conclusions discovered in phase 5 were compared and combined in case of overlapping. Then final conclusions were formed and presented in Chapter 4.2.

The main advantage of utilizing the Affinity diagram method was being able to analyze the relatively large amount of qualitative data in a systematic manner. Figure 8 illustrates the Affinity diagram procedure.

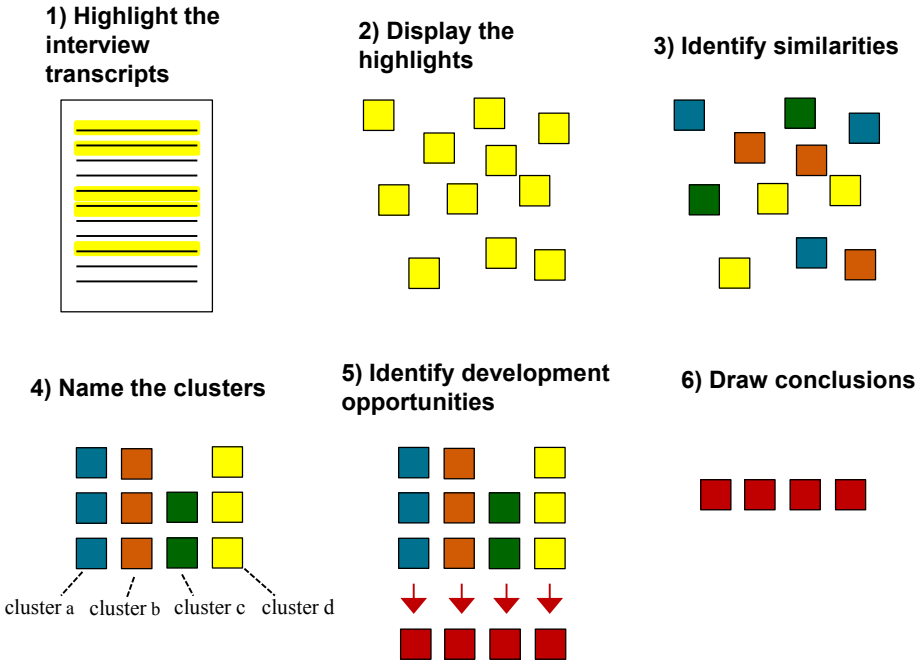

Figure 8. *Affinity diagram method (adapted from Sahramaa 2013, p.60).*

4.2 Conclusions of the Interviews

The interviews were analyzed in a systematic manner as presented in Chapter 4.1. The seven themes discussed in Subchapters 4.2.1 – 4.2.7 reoccurred. The themes correspond to the themes of the interview questions (Appendix A), which was expectable, since the interview type was a semi-structured interview. Semi-structured interviews base on a list of open-end questions according to themes (Subchapter 2.6.1).

The first subchapter presents the respondents' opinions for and against the current FMLTP model. The following subchapter discusses the current process for managing the FMLTPs as well as the improvement suggestion for the process. After that, the third subchapter presents the identified stakeholders, who according to the respondents, should collaborate in FMLTP decision making. The fourth subchapter reveals the identified products, which the interviewees underscored to need FMLTP improvements. The next two subchapters gather together both the replies about competitors' delivery times and overall market need. The last subchapter reviews the replies about the availability based lead time assignment model.

4.2.1 Theme 1: Case Company's FMLTP Model

Replies about the advantages and disadvantages of the current FMLTP model were noticeably coherent. Table 7 summarizes the answers.

Table 7. *Pros and cons of the current FMLTP model.*

Pros	Cons
FMLTPs simplify operations: • eases selling • easy administration • automates the process • easy to communicate to the stakeholders	Flexibility is needed. Ineffective communication between sales force and production planning required every time when the standard FMLTPs do not fill customer requirements.
Good for small orders, especially for configurable products	Predefined strict classification causes problems: order splitting
"No negative feedback heard"	Medium class is needed
	FMLTPs do not match with market needs: • quantities included in the current classes • problems with delivery times of big orders

Simplification. The interviewees concurred with the opinion that FMLTPs simplify and ease the case company's operations. The case company has sales representatives all over the world but the majority of production and production planners are in Finland. FMLTPs allow the case company's sales representatives to sell predefined quantities with predefined manufacturing lead times at anytime, anywhere in the world without the need of confirming production capabilities from the instrument factory. The Production Planner confirmed that the FMLTPs simplify daily operations as long as the customer is satisfied with the offered FMLTP.

Several respondents underlined that the FMLTPs make the work more efficient between sales and production planning. According to this, respondents seemed to consider that if

the case company would not have the FMLTPs, it meant that sales persons should enquire production planning for the order specific manufacturing lead time for every single order – similarly as currently is done for all On Request orders. This viewpoint reflected the answers on simplification. On the other hand, these answers revealed how deep rooted the FMLTP model is in the case company, because only a few respondents could consider a possibility of having a a different model (e.g. ATP) for defining manufacturing lead times.

One Regional Sales Manager emphasized that the FMLTP model eases customer's production planning process too. The FMLTPs enable the case company's sales and marketing to communicate the case company's production capabilities to the customers by promising fixed manufacturing lead times for orders of certain size.

Small orders. Generally, the FMLTP model performs especially well with small orders of configurable, high quality products. The respondents agreed with each other that in this product category the case company's delivery times are rather a competitive advantage. The LCM Manager noted that the three day FMLTP is a great achievement for these high quality products, since every product is configured to customer specifications.

The case company has tens of thousands of orders annually and the great majority of them are small orders (see Subchapters 2.1.1 and Chapter 4.2). Thus, the need to handle these orders effectively is obvious. One Product Manager concluded that every practice that simplifies the great number of transactions is favorable.

No negative feedback. A couple Product Managers justified the current FMLTP model to be good just because they had not heard negative feedback. Some other Product Managers said that the only problem with the FMLTPs has been occasional problems of keeping the promises. Generally, Product Managers appeared to be more satisfied with the FMLTPs model than the other stakeholders.

On the one hand, the contradictory opinions between different stakeholder groups indicate that the FMLTPs and their identified problems are not openly discussed. On the other hand, as Product Managers are responsible for certain product families only, the contradictory opinions suggest that some product families might have fewer problems than the other product families with the current FMLTPs.

Lack of flexibility. The deficiencies, as listed earlier in Table 7, derive mostly from the lack of flexibility in the FMLTP model. Accommodating fast occurring customer needs requires extra communication between sales and production planning. The Production Planner explained that each production planner receives 1 to 10 requests per day to expedite the FMLTPs for specific orders. All these requests need to be manually processed. She continued that it is difficult for the sales representatives to understand why some products may be expedited and some not.

Production Planners waste their time also correcting order entry mistakes. The Production Planner noted that order entry mistakes occur due to humane errors by salespersons. Salespersons have to check the FMLTP and calculate the manufacturing due date manually.

These communication and manual checks delay sales and bidding process, which might eliminate the competitive edge of the short FMLTPs. The interviewees highlighted that the need to reduce the amount of the discussion needed should be one of the main priorities in developing FMLTP model.

Strict classification. According to the respondents, the rigidness of predefined FMLTP classification is one of the greatest problems in the FMLTP model. One additional product may bump the delivery time from less than a week (Small Standard) to over 4 weeks (Large Standard). One Regional Sales Manager stated straight away that customers do not understand this logic. Many interviewees revealed that salespersons often split large orders to several order lines. In such cases the salesperson divides one large order to two or more smaller orders and is thus capable of promising shorter delivery time and accommodating the customer's requirement for fast delivery. Obviously, order splitting may cause problems to production and threaten the case company's ability to deliver the sold products on time, because the capacity need may be much higher than planned before. In principle, order splitting is prohibited but in practice it seems to be a tacitly approved convention.

However, one Business Segment Director told that she was upset as she first heard about order splitting. She said that order splitting clearly implies problems in the FMLTP model. Furthermore, the split orders create more expenses from handling and shipping more order lines.

As a solution for getting rid of the need to split orders and to address the customer needs better, many respondents proposed implementation of Medium Standard classification to a wide range of product families beside the pilot product family. Medium Standard would serve the medium-size orders with manufacturing lead time between three days and four weeks – e.g. two weeks. Generally, the respondents considered manufacturing lead time of four weeks to be too long delivery time except for very big orders.

Mismatch with the market need. The interviewees exemplified that the mismatch to the market need ascribes firstly from the too small quantities that are permitted to be sold within Small Standard classification, and secondly, from too long delivery times for large orders. The replies imply that a three day manufacturing lead time is short enough in the most cases. One Regional Sales Manager noted that the case company's FMLTPs may look better than they are in reality, because the number of large orders is still low.

The respondents considered the FMLTPs for small orders as an advantage whereas many interviewees, especially Regional Sales Managers, noted that large orders cause

problems. Large orders have high significance to total sales volume and are, therefore, important to the case company (Chapter 4.4). One Regional Sales Manager expressed her worries that the case company is not focusing enough on big orders. She explained that it is essential for the growth strategy to serve big customers and large orders better. The reasoning behind this is understandable. It requires much more resources to gather and serve 50 small customers, who order one single product every now and then as compared to serving one big customer who orders 50 pcs or more at once. To attract these large customers the case company needs, as another Regional Sales Manager told, to improve large orders FMLTPs without neglecting high-profit small orders. One Product Manager expected the amount of large orders to rise in future, because the case company had done changes in pricing favoring large orders.

4.2.2 Theme 2: Process for Managing FMLTPs

Current FMLTP creation. The case company does not have a clearly defined and communicated process for managing FMLTPs. One Business Segment Director told that she feels like the FMLTPs are "created in a black hole". She explained that she does not know how the decisions are made and by whom. According to her, the FMLTPs have, for some reason, fallen to no-one's responsibility. Even one Product Manager, who has been involved in FMLTP decisions, admitted that he does not know whether the case company has any process for managing the FMLTPs.

The LCM Manager clarified that NPI process contains only a reminder that the FMLTPs have to be defined at a certain phase of the NPI project but nothing more. Product Managers explained that those participating in the FMLTP decision making are normally a Product Manager and a LCM Project Manager. Product Managers explained that typically FMLTP decisions are justified by comparing the new product to existing comparable products. This means that the new products get similar FMLTPs as the old corresponding products. One Product Manager admitted that the FMLTPs are "more or less the Product Manager's guesstimates". That implies that the FMLTPs are often created without thorough deliberation.

Giving similar FMLTPs to a new replacement product as the former-generation product had, is justifiable if the market need is truly known and the old FMLTPs provably address the market need. However, the threat is that the old market need misestimates recur.

The market need is much more difficult to estimate for novel products. Even though it may require a great effort to estimate the market need, it should not be neglected. A misestimated market demand causes remarkable problems – problems that are costly and slow to fix. The Head of Instrument Factory revealed that the case company has "too often" launched a product with FMLTPs that already initially failed to address the market need. She elucidated that such mismatch results in immediate delivery problems

and continued that to fix the problem, OPS (Operations) should rebuild the whole supply chain, which is an expensive and time-demanding task.

FMLTP factors. The interviewees provided a list of factors that should be taken into consideration as the FMLTPs are defined. Figure 9 gathers the factors together and concludes their relations according to the replies. The three main categories are Customer Need, Product and Supply Chain.

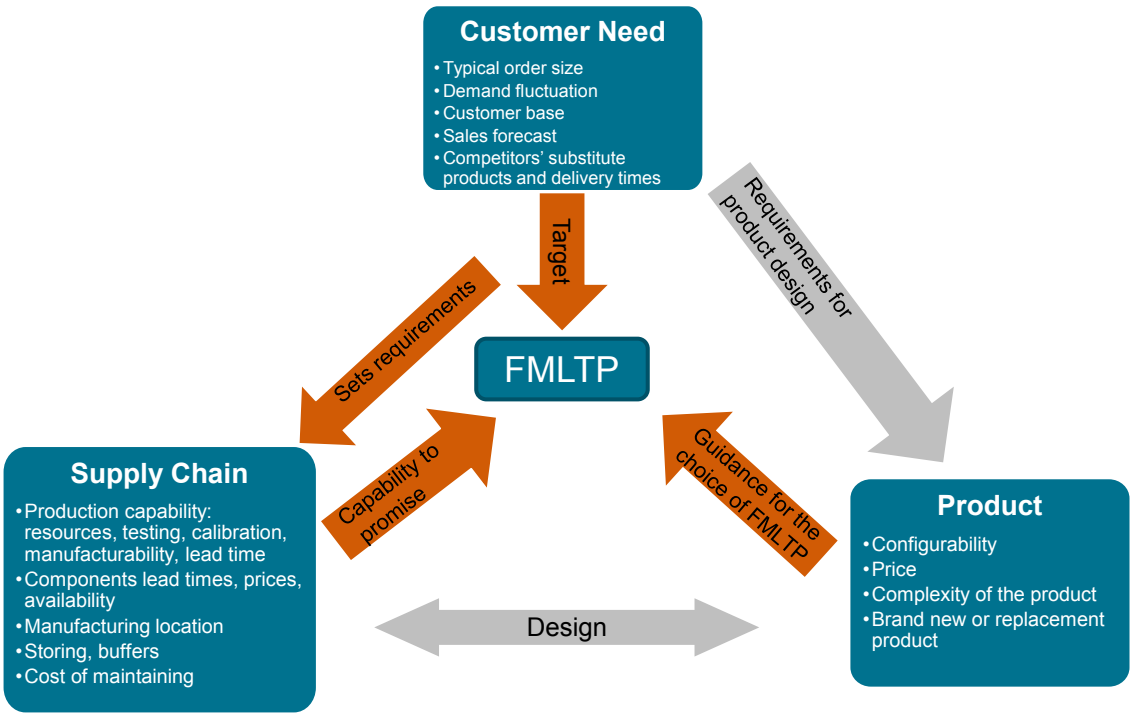

Figure 9. *Identified factors and their relations.*

The respondents emphasized that **Customer Need** should be the starting point for the FMLTP decisions. Specifically, they underlined the high importance of understanding the customer need in terms of typical order sizes and demand fluctuation. The customer need depends on the customer base and market segment. The respondents clarified that the case company operates in versatile market segments. They explained that the case company's customer base ranges from small customers in the stray markets to large institutions in project markets. In the stray markets thousands of unique customers order single products whereas in project business fewer customers require significantly large deliveries. In addition, competitors' delivery times and substitute products build up the level of customer expectations. LCM Manager summarized the significance of understanding the market needs. She told that if customer needs are acknowledged they can be expressed in an amount that has to be delivered within a certain time frame – which, in other words, should be the target for the FMLTP. This target, she continued, is the corner stone for the whole NPI project, because the production and supply chain capabilities must be aligned with those target delivery times.

Supply Chain constructs the capability of promising certain FMLTPs. Obviously, production capacity affects the capability of promising FMLTPs. The interviewees highlighted also the following factors: components' availability including lead times and prices; storing and buffer decisions; manufacturing location; and cost of maintaining supply chain. Several interviewees emphasized the cost aspect. For instance, one Business Segment Director said that the desired FMLTP capability and the cost of maintaining the supply chain have to be optimized. He noted that every wish for a FMLTP cannot be fulfilled, because the maintaining expenses would be too high.

The factors listed in **Product** category help to approximate the suitable FMLTP. In Subchapter 4.2.6 the respondents explain that, for instance,. price and configurability have an effect on the expected delivery time. They suggested that customers accept longer delivery times for more complex and more expensive configurable products. As mentioned earlier, the existing products' FMLTPs provide guidance for the choice of FMLTPs for the new product.

The interrelationship of the Customer need and product design and product development is not discussed within this thesis. Similarly, product design has an effect on supply chain decisions and vice versa but it is likewise excluded from the scope of this thesis.

FMLTP revision. Most of the interviewees desired revisions with the FMLTPs according to a predefined process. One Product Manager underlined that one problem of the current FMLTPs model is that it is very seldom checked whether the FMLTPs are still suitable from the customers' point of view. Especially the Regional Sales Managers wanted the FMLTPs to be reviewed regularly. One Business Segment Director agreed that the case company should have the attitude that once defined FMLTPs are not permanent. He said that the performance of the FMLTPs should be tracked in systematic manner. If some FMLTPs are identified to cause problems, the company should react accordingly. A systematic time-based tracking of FMLTPs enables making proactive corrective actions.

However, the replies vacillated with the question on the need of having a regular FMLTP review. Some Product Managers were of the opinion that a regular review is not needed. One Product Manager argued that the need to revise FMLTPs arises itself already from the salespersons or from production, and thus no internal process to trigger the revision is needed. Nevertheless, it is questionable, how the need to revise FMLTPs arises and triggers FMLTP evaluation and revision, since the sales data analysis clearly indicates (Chapters 4.3, 4.4 and 5.3) that the current FMTLPs have much room for improvement. Additionally, the interviewees told that the FMLTPs are revised very rarely and no-one of the respondents told that FMLTPs are discussed between separate business functions. One Business Segment Director highlighted the need to have a procedure for escalating FMLTP revision. She explained that if someone in the organization

notes that a particular FMLTP causes problems, the case company should have commonly known means to get the message through to start evaluating the need to improve the FMLTP.

Drivers to trigger the FMLTP review. Because of the need of revising the FMLTPs, the interviewees were asked to identify drivers that should trigger the FMLTP revision. The following four drivers were repeated in the answers.

1. Demand Changes
2. Customer Requests for different FMLTPs
3. Product Life Cycle
4. Changes in Supply Chain Capability

All interviewee groups identified **demand changes** to be one of the key drivers. For instance, the Production Planner proposed that, a preferably automated, demand forecast vs. FMLTP analysis should be conducted on a regular basis. The Head of Instrument Factory exemplified why demand changes are important to follow. Demand changes affect the sales forecast, which has a significant effect on the supply chain capability. A sales forecast is shared with suppliers. Hence, as sales forecast shrinks remarkably, suppliers lower their inventories and the case company's supply chain capability weakens. That exposes to risk of future delivery delays. The Head of Instrument Factory explained that in case of remarkably lowered sales forecast, the case company should lower the FMLTPs respectively.

Likewise, the respondents suggested that if the demand proves to be much higher than expected, the FMLTP review process should be initiated. Decisions should be thoroughly considered. As one Product Manager emphasized, a demand change should be durable and significant before the FMLTPs are considered to be revised. Correspondingly, one Business Segment Director emphasized that FMLTP revision requires "a mass of evidence" before the FMLTPs are revised.

Mainly the Sales Managers brought up the point that the case company should track the amount of **customer requests** for order specific FMLTPs. This point is understandable as a salesperson always has to enquire production planning if they need expedition for a FMLTP. Tracking the expedition request indicates which are the products whose market need is for faster deliveries than the case company's FMLTPs enable. Secondly, the respondents underlined the need to check whether the case company promises unnecessary FMLTPs. Unnecessary promises mean maintaining capability for FMLTPs that customers do not use. One Business Segment Director summarized that the case company has to look at these two sides. Firstly, does the market need indicate that the case company has to introduce a new FMLTP or revise the quantities of the FMLTPs. Secondly, the FMLTPs should be analyzed and checked in case there are some promises that no-one uses that only create costs for maintaining the ability to promise.

As mentioned earlier, several interviewees proposed that the FMLTPs should be reviewed annually. One Regional Sales Manager specified that FMLTP improvements should be done, if needed, to products that produce the most of the gross revenue. He suggested a concrete measure: if 80% of deliveries are delivered according to standard FMLTPs, the classes are correct. For example, one Regional Sales Manager and one Business Segment Director proposed that the trigger for FMLTP revision could be the amount of FMLTP speed up requests. The products that receive most requests should be reviewed carefully.

The third widely recognized driver for FMLTP revision was **product life cycle**. The interviewees shared the thought that during the ramp up phase FMLTPs could be raised in line with raising sales volumes. The LCM Manager mentioned that this convention is actually already adapted. When a product is launched the whole capacity is not typically in use or the capacity is not needed completely because sales volumes are still low. In such cases it is wise to have lower FMLTPs and raise them later as the sales volumes get stronger, she explained. At the end of the life cycle short FMLTPs could be removed, which de-emphasizes the ramp-down product to sales and maintaining unnecessary capacity or inventories is not needed, one Regional Sales Manager and LCM Manager explained.

Lastly, some interviewees highlighted that remarkable and durable changes in **supply chain capability** should trigger the FMLTP revision. For example, the Head of Instrument Factory explained that FMLTP revision should be initiated, if the case company has to introduce a new production phase that slows down the production process, or, alternatively, if there appears significant material availability problems that the case company is not willing or able to fix. The Regional Sales Manager added that the learning curve effect should be noted. Over time, when a product is manufactured, the problems should disappear and thus improve the production capacity and enable FMTLP improvement.

4.2.3 Theme 3: Stakeholders

Table 8 lists the stakeholders that the interviewees considered to have a relevant role in FMLTP decisions. Primary stakeholders are persons, or business functions, who the interviewees considered to be the key participants or the source of information for FMLTP decisions. Some interviewees specified also secondary stakeholders. Secondary stakeholders are stakeholders who have a relevant but not a crucial role in FMLTP decisions. According to the interviewees, secondary stakeholders should be informed about FMLTP decisions.

Table 8. *Identified stakeholders.*

Stakeholder	Total number of mentions by respondents (of which secondary mentions in brackets)	Remarks
Product Manager	13 (0)	Mentioned by only 2 Regional Sales Managers
Sales	13 (3)	Only 1 Product Manager identified as primary stakeholder, 3 Product Managers identified as secondary stakeholder
LCM representative	9 (0)	0 mentions by Sales Managers
Production Planning	8 (1)	
Sourcing	6 (1)	
Business Segment (profit-loss responsibility)	6 (2)	Business Segment Directors did not mention themselves
OPS	30 (10)	•Operations 5 (1) •Team Leader 5 (1) •Production 4 (0) •Production Testing 4 (2) •Material (supply) Chain 4 (3) •Process Engineer 4 (1) •Head of Instrument Factory 1 (0) •Somebody from factory 1 (0) •Shipping 1 (1) •Logistics 1 (1)
Other Stakeholders	6 (0)	•Different Regions 3 (0) •Project Management 1 (0) •PLM Business Owner 1 (0) •Controlling 1 (0)

The Table 8 shows that Product Managers and sales are the most often mentioned stakeholder groups. Nevertheless, the sampling of the respondents might have caused a bias. Product Managers and Regional Sales Managers are the interview groups that had most respondents, 7 and 7 respectively. Furthermore, attention should be paid to that each interviewee group considered themselves as the main stakeholders participating in FMLTP decisions except the Business Segment Directors. Product Managers and sales are followed by the LCM representative, Production Planning, Sourcing and the Business Segment. These five groups had 6 to 9 mentions. In turn, the stakeholder groups that received 5 or less mentions are grouped under Operations and Other Stakeholders. The two latter groups subsume in total 15 at least once identified stakeholder accounts. The total amount of 22 separate stakeholder groups indicates how manifold the implications of the FMLTP decisions are to the whole case company.

Noticeably, the Product Managers and the Regional Sales Managers did not, mostly, consider each other as primary stakeholders. In fact, 4 out of 6 Regional Sales Managers

did not mention Product Managers at all, whereas only one Product Manager identified sales as a primary stakeholder and three out of seven Product Managers did not mention sales at all. The other respondents mentioned the both stakeholder groups. Regional Sales Managers either mentioned LCM representatives, who actually collaborate with the Product Managers in current FMLTP decisions (see Subchapter 4.2.2). It indicates that the FMLTP decisions are not communicated to salespersons, since otherwise at least couple of Regional Sales Managers would probably have mentioned LCM representatives who are deeply involved in NPI projects. The FMLTPs are defined in NPI projects as Subchapter 4.2.4 brings up. In addition, the revealed results of merely a few mentions that Product Managers received from Regional Sales Managers are surprising. Namely, several Product Managers replied that they communicate to the sales department and added that the LCM representative is responsible for contacting the stakeholders of OPS. Some Product Managers formulated this saying that the Product Manager "represents" sales in FMLTP decisions. On the contrary, one Product Manager responded that the salespersons must not necessarily be involved in FMLTP decisions. Another Product Manager acknowledged that he has "not discussed much" about the FMLTPs with the sales persons.

Production Planning and Sourcing received substantially many mentions considering that only one production planner and no-one from the sourcing department was interviewed. That indicates strongly that these stakeholder groups are important to take along in the FMLTP decisions. In fact, the Production Planner made it clear that production planners want to participate in the FMLTP decisions. She explained that, at the moment, production planners are typically merely informed after the FMLTPs are decided. Moreover, she added that sometimes they have had to ask for the decided FMLTPs themselves, as the information has not reached production planning.

The many mentions of the stakeholders that are included in the OPS stakeholder category imply that the respondents identified that the OPS has to be definitely included in the FMLTPs decisions. Some scattered mentions of the subgroups of the OPS stakeholders and general answers such as "operations" and "production" reveal that the respondents were commonly unable to particularize who are the main stakeholders in the OPS. The Respondents emphasized, however, that FMLTP decision making should be finally made by a few selected stakeholders. Thus, the solution could be that the selected primary stakeholders informed secondary stakeholders and gathered comments from them. In any case, deeper collaboration and communication between the departments is needed. Poor communication was apparent both in the answers about the unclear process (Subchapter 4.2.2) and in these answers about the stakeholders.

4.2.4 Theme 4: Products

The question 4 asked the respondents to provide concrete examples of products whose FMLTPs they considered to need improvements. Table 9 summarizes the replies.

Table 9. *The products and their FMLTPs that the interviewees highlighted to need improvements.*

Volume and price category	Product name	Remarks
High Vol. €€€	ProductName	• Had much problems but Medium Standard might have solved problems.
	ProductName	*• 3 day Small Standard maybe unnecessary promise*
High Vol. €€	ProductName	• Too big proportion of the sales volume in on request class. ProductName should have similar FMLTPs.
	ProductName	*• 3 day Small Standard maybe unnecessary promise*
	ProductName	• 50 pcs in Large Standard is not enough
High Vol. €	3 Products	• Medium Standard needed; Small Standard could be possibly longer: 5-7 days, but with higher quantities
	ProductName	*• Large, 50-100pcs, quantities wanted faster*
Medium Vol. €€€	3 Products	• Medium Standard needed
Medium Vol. €€	4 Products	• Medium Standard needed
	ProductName	*• Initially completely wrong defined FMTLPs*
	ProductName	• Shorter FMLTP than 3 days is needed
Medium Vol. €	ProductName	• Should have similar classes as the comparable products
	ProductName	*• Medium Standard needed*
	6 Products	• Medium Standard needed; Too much of the sales volume in on request class.
Low Vol. €€	ProductName	• Medium Standard needed
Low Vol. €	6 Products	• Medium Standard needed

The products are grouped according to their sales volume and price. Subchapter 4.3.2 describes the categorization in detail. The replies were somewhat scattered and did not reveal category-specific improvement opportunities. However, some replies repeated themselves. The respondents suggested introducing Medium Standard FMLTP to most products that they identified to need improvements. The recently introduced Medium Standard classification to the pilot product family probably affected to the answers, since the gap between 3 days Small Standard and 4 week Large Standard was that re-

markable that it feels like an obvious answer that "Medium Standard would be good to this product as well". Likewise, the replies that similar kind of products' FMLTPs should be unified were repeated.

The respondents pointed out also four other development possibilities. Firstly, data logger products had too long delivery times according to the Production Planner and one Business Segment Director. However, the case company had identified the data logger problem earlier and improved the delivery capability and FMLTPs already during this thesis. Secondly, one Regional Sales Manager pointed out that the spare parts the case company sells have too long delivery times compared to the products. Thirdly, one Product Manager brought up that the distribute products have, likewise, too long delivery times. Distribute products are products that the case company buys from subcontractors fully assembled and does only the branding and packaging to them. The last point, noted by one Regional Sales Manager was that he considered the lead time of Calibration and Repair Services to be too long.

4.2.5 Theme 5: Delivery Times Compared to the Competitors

The competitors' delivery times are not well known at the case company. The Head of Instrument Factory summarized the situation: "I don't have knowledge about the competitors' delivery times. I only know that they are not well known in this house". 5 out of 18 interviewees admitted straight that they don't know the competitors' delivery times. One Business Segment Directors told that competitors' delivery time information is not collected systematically. Another Business Segment Director explained that information about competitors' delivery times is obtained mainly as competitors' products are ordered via a straw person or when sales receive occasional feedback from customers. Regarding ordered products, one Product Manager responded that competitors' products are delivered quite slowly as compared to the case company's delivery times.

Most interviewees had only vague opinions about the case company's FMLTPs compared to competitors' delivery times. For instance, one Product Manager deemed that the case company has better delivery times than competitors on average, whereas another Product Manager reckoned that competitors have probably approximately equal delivery times to the case company. One Segment Director supposed that the case company's three day class is competitive and stated that the competitors tend to have rather 1-2 week delivery times – even though she acknowledged that the case company's three day FMLTP is practically a one week delivery time from the customer's perspective. Contrastively, one Product Manager argued that instrument manufacturers have typically 4-6 weeks delivery times. Several interviewees supported the statement that Small Standard, that is, 3 day classification is competitive but the 4 week Large Standard is another question. A possible reason for contradictive answers is that as some interviewees are specialized in one particular market segment their answers reflect the case company's competitive position and typical delivery times on those particular markets.

Even though the replies presented above vacillated, the respondents had a surprisingly coherent view that the case company's FMLTPs provide competitive advantage within configurable products. The case company's ability to deliver configurable products with a 3 day FMLTP is an advantage, summarized one Business Segment director. Several Regional Sales Managers verified that FMLTPs are advantage for small orders of configurable products, albeit, one Regional Sales Manager underscored that the FMLTPs are "still today" an advantage, but he mentioned that the competitors are undoubtedly improving their delivery times correspondingly.

Accordingly, the respondents coherently emphasized the fact that some of the competitors deliver products from stock (MTS production strategy). These competitors provide shorter delivery times than the case company. One Regional Sales Manager detailed that these MTS competitors exists mainly in markets of simpler, less configurable products such as HVAC (Heating, Ventilating, and Air Conditioning) products. Another Regional Sales Manager told that these MTS competitors provide next or even same day deliveries.

One possible drawback of selling from the stock is the possibility that customer receives the product with a several weeks old calibration certificate as one Regional Sales Manager explained. The high-precision instruments must be calibrated regularly to provide high-quality data. Thus customers prefer to buy recently calibrated products. Although this thesis does not cover MTS versus ATO or MTO decisions, it should be noted that changing production strategy from ATO or MTO to MTS is not the only mean to compete with the MTS competitors. Business Segment Director explicated that finding distributors to store and selling the case company's products is an alternative for MTS production strategy. He proposed that this approach would also be beneficial for the customer, since customer the buys also other products from the same distributor.

None of the interviewees surmised that the case company's FMLTPs would induce losing remarkably many orders. One Regional Sales Manager described that the case company loses orders only in case the case company has production or material availability problems and standard FMLTPs are prolonged. He added that, however, the case company does not always hear the reason why customer rejected case company's bid. The reason for a lost bid might be, for instance, a result of unsuitable product specifications, price or too long delivery times. One Product Manager argued that when the case company has delivery disruptions it "does not lose that many" bids. He alleged that only customer orders would be postponed.

The consequences of lost orders might yet be remarkable. One Regional Sales Manager elaborated the impact of lost orders. He explained that if the case company does not have flexibility to accommodate and fulfill the market needs, it encourages customer to one-buy from a competitor. This exposes the case company to the risk that the customer buys from the same competitor also next time. The Regional Sales Manager summa-

rized that if the case company is limited or inflexible in terms of delivery times, the result is that the case company does not even receive these queries anymore.

Evidently, the competitors offer shorter delivery times in certain product categories. The need to improve delivery capability of these products needs to be considered thoroughly. One sales manager concluded the case company's position as compared to its competitors saying that in general, the case company has good delivery times which are better than those of their competitors' but the case company should not stop developing them. The Benchmark against the competitors is discussed in Chapter 4.5.

4.2.6 Theme 6: Market Need

Regional differences. The market need differs across separate regions. One Business Segment director brought up that **China** has proportionally more large orders than the other regions. Several interviewees verified this. For instance, the Head of Instrument Factory replied that according to her empirical experience, the market need in China exists for large deliveries with comparably short delivery times. Similarly, one Product Manager said that big batches are usually sold to China.

The request for exact, JIT deliveries is distinctive to Japanese customers. The Regional Sales Manager of **Japan** verified that exact deliveries and product quality are extremely important in Japan. He noted that to ensure the exact deliveries small buffer storage is kept at the case company's Tokyo office.

Thirdly, the respondents explained that the need for fast small amount deliveries occur specifically in the **USA**. Some customers expect even same-day deliveries. The Regional Sales Manager of the USA stated that a certain market need for same day deliveries exists in the USA. He continued that the need for same-day deliveries might be of a small value, but emphasized that if the case company is not willing to accommodate with that customer need, it decreases customer experience and satisfaction, which might expose the case company to lose these customers. The Business Segment Directors supported his views. One Business Segment Director agreed that there are more fast sales (small amounts, many orders) in the USA than in other regions. Another Business Segment Director noted, like the Regional Sales Manager of the USA, that the market need for the same- or next day deliveries is not yet significantly high. However, she expected that the demand is changing to even shorter delivery times especially in the North America, which she told she had noticed as she lived there. People are accustomed to very fast B2C deliveries, which reflect to B2B markets.

The Interviewees brought up also additional burdens that exist generally in **emerging markets**. For instance, in certain countries that have protectionist policies, customs may cause significant delivery delays. The respondents exemplified that products may get stuck in the customs even for weeks at the worst case scenario. The respondents ex-

plained that such delivery problem rarely depend on the case company itself or the customer, and are thus problematic to fix.

Even though positive evidence of diverse market needs in separate regions exists, the interviewees did not consider regionally differing FMLTPs as a feasible solution. The reasoning against it was that it would result in a more complex model and create inequalities. One Regional Sales Manager added that since the case company has the same gross profit expectations in all the countries, the factory needs to support each country in the same way – hence, unless the case company wants promote one country specifically, the case company should not have regionally specified FMLTPs. Nonetheless, time zone differences should be taken into account in the FMLTP model, which the Regional Sales Manager of Japan emphasized. Actually, it is already considered in the FMLTP model. The guidance for calculating the manufacturing due date for Small Standard, is that the manufacturing due date is the third working day in the instrument factory counting from the next working day. Thus, it does not matter from which time zone the order is booked; every order receives the same manufacturing lead time in the instrument factory.

Market needs for different product types. The interviewees generally shared the opinion that the FMLTPs are good for small deliveries for **configurable products** as stated in Subchapter 4.2.5. The respondents clarified that the customers do understand that manufacturing highly configurable products according to the order takes more time. Nevertheless, as addressed in Subchapter 4.2.4 the respondents hinted that, generally, configurable products would need Medium Standard FMLTP classification or alternatively larger amounts allowed in the Small Standard FMLTP.

For **cheaper, non- or low-configurable products**, such as many HVAC products customers expect short delivery times. Sales Managers stated that the customers expect the case company to have these products in stock, since several competitors manufacture them with the MTS production strategy (Subchapter 4.2.5). The competition in this product category is fierce, because many rival companies provide substitute products. One Business Segment Director explained that the competition is very stiff, because many competitors produce “completely okay” products. One Regional Sales Manager replied that the customers choose the case company because of the good reputation and reliability, but added also that less is enough in terms of product quality, which means that if the case company’s delivery times are not competitive, the customers choose the competitors’ products.

Market need for short delivery time. The respondents considered the problem to be more on the quantity that can be sold with the Small Standard (3 days) FMLTP than in the length of the Small Standard FMLTP. One Business Segment Director explained that the case company has not got any signal that the business would get any better if they shortened the Small Standard from three days to two days. In contrast, one Region-

al Sales Manager said that within some time period the three day class has to be changed to two days.

In any case, a certain market need exists for same or next day deliveries – i.e. Fast Track in the case company's FMLTP classification. One Sales Manager stated that the customers expect 1-2 pcs orders delivered in the maximum of 2-3 days. Regarding the need to Fast Track deliveries, another Regional Sales Manager underscored that the need for the small quantity but very fast deliveries might seem too small when the sales data are analyzed. The assumed reason is that the customers do not contact the case company but they choose a vendor who is known to have immediately available substitute products. In other words, according to him, the market need for Fast Track orders of simple HVAC type products probably seems too low. Contrastingly, for products for which there are not as many substitute products (high quality, configurable products), the need for fast deliveries arises immediately and is visible in a higher number of Fast Track orders.

Market trends. Several interviewees emphasized the customer need for timely deliveries. The promised FMLTPs have to be kept. Additionally, the respondents highlighted the customers' interest to have a greater visibility to current availability of products. This reflects the B2C e-commerce. People are used to getting an instant overview of availability information and the expected delivery time before placing the order. This B2C markets' trend and the trend of minimizing storages are the key drivers to change case company's B2B markets. One Product Manager summarized that in the era of e-shopping the customers are used to short delivery times in private life, which B2B markets reflect, which again will change the common understanding of the delivery times.

Generally, the respondents held an opinion that the market demand is moving towards shorter delivery time requirements. In Subchapter 4.2.1 it was already pointed out that large orders cause problems. The LCM Manager expected the demands for fast deliveries of large orders will increase. One Business Segment Director added that the case company's business is going towards having more demand pikes caused by single large orders.

One Product Manager elaborated the factors behind the need for short delivery time. He explained that the need for fast deliveries stems from inventory optimization. The customers tend to have smaller inventories nowadays, which means that they want to commit and order products as late as possible to reduce expenses, as explained by one Business Segment Director. A promptly delivery is needed especially, if the product is a part of a bigger process and a product malfunction appears. Then the replacement product is needed swiftly in order to prevent bigger process from having a long stoppage. Another Product Manager pointed out that the case company's customers' buying organizations have often slow processes, and, as the purchasing decision is finally made,

they require quick delivery. The latter point pertains only to certain customer segments such as governmental customers.

Many respondents expect that the inventory optimization leads to higher amount of small orders. One Regional Sales Manager concluded that the case company will definitely have more small orders in the future because the customers minimize their storages. He added, however, that the case company will still additionally have some customers that order large infrequent orders. The Head of Instrument Factory said that the shift from large orders to frequent small orders has been expected to happen already for a longer time but the change has not yet taken place. She elaborated that it has been surprising that the amount of small orders has not grown even though that could have been assumed in the world where Lean manufacturing is the trend. She added that medium to large orders have surprisingly large proportion of the case company's total sales volume.

In conclusion, the marked need differs between regions but the respondents did not consider market specific FMLTPs as a solution to respond these needs. Market competition is harder in the markets of cheaper more, commodity type of products, where several rival companies provide substitute products. A certain demand for same-day or overnight deliveries exists. The demand for fast deliveries is likely to strengthen, although also the ability to respond to large orders and deliver them promptly is needed.

4.2.7 Theme 7: Availability Based Lead Time Assignment

Availability based lead time assignment models (e.g. ATP) for defining order specific manufacturing lead time are widely used in industry (Chapter 3.3). The question 10 (Appendix A) encouraged the respondents to ponder the suitability of an availability based lead time assignment model to the case company.

The interviewees' opinions on the need and suitability of such availability based model for manufacturing lead time definition were divided into three groups: those who supported the idea of having availability based lead time promise assignment model; those who had a neutral opinion or did not have a clear opinion; and those who considered availability based model unsuitable for the case company's business. Table 10 summarizes these replies.

Table 10. *Opinions about availability based model for manufacturing lead time promise determination.*

For availability based model	Neutral opinion	Against availability based model
The best concept would be a ERP system retrieving automatically the available manufacturing lead time	A combination of an availability based model and FMLTPs would work	Delivery time (manufacturing lead times) should not vary too much
Better to look availability and provide exact delivery dates. Sales could be more certain about the delivery (shipping) date.	FMLTPs should be upper boundaries for the delivery time and according to availability faster deliveries may be offered	If the availability based model increased the amount of non-value adding communication between sales and production planning, it would be a bad thing.
It could reduce the amount of ineffective back-and-forth emails between production planners and sales.	It would be interesting to hear more about this: what would it mean in practice: how often would the deliveries be faster, how often slower?	FMLTP model is more transparent. Customers would need to ask about delivery time every time.
Could fit especially to large orders.	So far availability based model is considered unrealistic	Might be confusing
		Single big orders might reserve the whole capacity

As recognized in Subchapter 4.2.1, the current FMLTP model adds burden to process in the form of abundant communication between sales and production planning, when flexibility to accommodate expedited manufacturing lead times is required. Those who stood for availability based model deemed that it would be a solution to reduce the time spent in non-value adding communication concerning the expedition requests.

Other advantage that was seen would be a higher certainty for delivery time as order acknowledgement is done. The salesperson could be sure that sufficient capacity exists to in order to fulfill their order in time. Thus, these respondents expected that an availability based lead time assignment would have a positive effect on OTD.

One Sales Manager underlined that if the availability based lead time assignment model is chosen, the lead time retrieval should be automatized, because the case company handles tens of thousands of order lines annually. That is a clear objective, because manual capacity and material checks would not be possible due to limited resources.

Several respondents considered the availability based model to suit, specifically, handling large orders. For instance, one Product Manager said that a real time manufactur-

ing due date retrieval for large orders would be great. Nevertheless, the respondents recognized the threat of large orders reserving too large a proportion of the available capacity, which could result in unacceptably long delivery times for the subsequent small orders. On the contrary, one Regional Sales Manager argued that it would not be a problem if large orders congested the production and prolonged the Small Standard deliveries. He justified that order delays happen already at the time of significantly high demands.

The majority of the interviewees argued that some framework for delivery times has to be available. Many considered a combination of FMLTPs and availability based lead time assignment as a potential option. As an example, one Regional Sales Manager said that the FMLTPs should be the base rule for the delivery times. The respondents emphasized that the salespersons need to have the ability to give some basic promise about the delivery times to be provided to customers anytime and anywhere, without the need to log in to the case company's ERP system. A couple of the interviewees proposed that the FMLTPs should act as upper boundaries for manufacturing lead time, and, according to capacity and availability, faster deliveries would be permitted. The contemplations to combine the FMLTPs and the availability based lead time assignment models are somewhat controversial. If the case company used automated availability based lead time retrieval model and had much demand, it could not pledge the FMLTPs concurrently and reliably. Clearly, using the availability based model makes the available manufacturing lead times shorter within periods of lower demand, whereas during periods of higher demand the available manufacturing lead times will be respectively longer, because of limited resources. Regarding delivery time fluctuation, several respondents maintained that delivery times should not waver much. The Distributor Sales Manager noted that stable delivery times are especially important for distributor sales.

One point to consider carefully is the requirements for availability based models. The respondents underscored that capacity information including operator, material and other resource availabilities has to be known and maintained up-to-date to get full advantage from the model. The Production Planner contemplated that a fully flexible, availability based model would be really difficult to maintain and it would take more time than the received cost savings. The Head of Instrument Factory supported this and proclaimed she does not believe that the case company would get a cost-effective solution to be fitted in its manufacturing environment.

The availability based model has definitely both advantages and possible disadvantages. Therefore, an in-depth analysis of its applicability to the case company's business environment should be conducted before any decisions. A general introduction to different availability based lead time assignment models is presented in Chapter 3.3.

4.3 Conducting Sales Data Analysis

The main objectives to be uncovered in the sales data analysis are:

1) Which products are sold according to the case company's standard FMLTPs? Are some products sold constantly with shorter or longer manufacturing lead time promises than the case company's standard FMLTPs are?
2) How the order lines and order volumes are distributed over the FMLTPs?

The hypothesis is that if the products are constantly sold with different manufacturing lead time promises than the case company's standard FMLTPs are, and, if the product has not had remarkable production disruptions, it indicates that the FMLTPs do not meet the market requirements. Similarly to the previous point, if a significant proportion of the sales volume is outside of the standard FMLTP classification (i.e. large proportion of On Request orders), that might indicate that those FMLTPs do not match with the market requirements.

Orders during production disruptions were removed in order to ensure that the data analysis could be interpreted according to the hypothesis. Subchapter 4.3.3 discusses the removal in more detail.

4.3.1 Data Collection

To assure representative sampling, the instrument factory sales data from the last two years were chosen to be analyzed. Out of that data, this analysis covers approximately the 90 most frequently sold products that had over 30 order lines at least. These products represent over 60 000 order lines. The products are all self-manufactured items. Figure 10 illustrates the sampling.

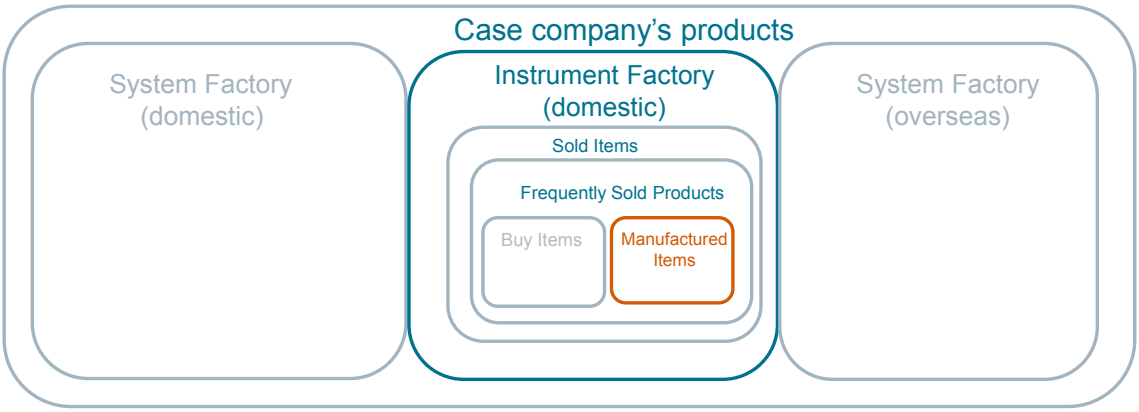

Figure 10. *Sampling of the sales data analysis.*

In order to be able to answer to the sales data analysis objectives (Chapter 4.3) the following data were needed of each sales order line

- Sales order number and sales order line
- Product name
- Total ordered quantity
- Booked Date (date when the order was created and released in ERP-system)
- Scheduled Ship Date (date when the production should be completed)

These data are stored in case company's ERP system. The case company's Controller and Supply & Demand Development Expert Specialist downloaded and provided all the needed data as Excel spreadsheets. In addition, the following data were utilized to calculate, compare and to make conclusions of the case company's standard FMLTPs:

- Production closure days
- List of standard FMLTPs
- Information about time periods of prolonged FMLTPs due to temporary delivery delays (Infomails)
- Product sales prices

The factory calendar, which presents production closure days, is available in the case company's intranet. Production was closed during weekends, in public holidays, factory inventory days and during occasional personnel training days. The list of the FMLTPs is also available on the intranet as well as in the ERP system. The FMLTPs have been defined according to the case company's delivery capability. An Infomail is the case company's manner to communicate temporary production disruptions to salespersons and other stakeholders. Production disruptions may be caused, for instance, by material availability problems or quality problems. These disruptions cause the prolonged FMLTPs. Lastly, product prices were needed to categorize the analyzed products.

4.3.2 Creation of the Analysis

Logic of analysis. The intention of the sales data analysis was to compare the sold manufacturing lead time promise (SMLTP) to the case company's standard FMLTP. Making this comparison required sorting, filtering and derivation of new parameters of the collected data. The analysis was done with Microsoft Excel. The calculations were done with simple Excel functions.

The following example demonstrates the logic of the analysis:

- Ordered product XYZ
- FMLTPs of Product XYZ:
  - Small Standard: 1-5 pcs 3 days;
  - Large Standard: 6-20 pcs 4 week;
  - On Request: 21 pcs or more
- (Order) Booked Date: 08/13/2014, Wednesday
- (Order) Scheduled Ship Date: 08/19/2014, Tuesday
- Total ordered quantity: 1

First, the sold manufacturing lead time promise (SMLTP) was calculated. SMLTP is the working days between the Booked Date and the Scheduled Ship Date.

The Scheduled Ship Date is defined by counting working days according to the FMLTP starting from the next working day (Case company 2013). Thus, in this example the SMLTP is 4 days, because the Scheduled Ship Date, Tuesday 19th, is the fourth working day counting from the next working day of the Booked Date, Wednesday 13th. Saturday and Sunday are excluded, because factory was closed then. Figure 11 demonstrates this logic.

Figure 11. *Counting of the Sold manufacturing lead time promise.*

Then a check, what the manufacturing lead time should have been according to the standard FMLTPs, was performed. Total Order Quantity was 1 pcs which belongs to Small Standard classification. Hence, the FMLTP according to case company's standard is 3 days.

The last phase was to compare, whether the SMLTP promise matched with standard FMLTPs or not. "OK"-, "Too Short"- or "Too Long" –definition expresses the result in the Excel analysis. In this case the SMLTP is "Too Long". Expressed in other words,

this order was sold with longer manufacturing lead time promise than the standard FMLTP is.

Additional assumptions and notes. Large Standard is four weeks. The Scheduled Ship Date is determined by adding the indicated number of weeks counting from the next working day (Case company 2013). Factory closure days during the four week period need not be considered when entering the order. This definition for Large Standard has been in use from 09/24/2013. The earlier definition was 18 working days taking factory closure days into consideration and counting from the next working day from the Booked Date (Case company 2013).

The change in Large Standard definition was taken into account. Until 09/23/2013 (Booked Date) the SMLTP is considered to be OK in case the SMTLP is within a range of 17 to 19 working days excluding possible factory closure days during working weeks. The Production Planner told that production planners did not usually intervene if salespersons, often because of a humane mistake, booked the order with a lead time one day shorter or longer than the standard was. Additionally, she added that after the new definition of Large Standard, the production planners accepted orders that salespersons booked with 18 days lead time. She mentioned that not all salespersons had understood the change of the definition. Taking this information into account and allowing again one day offset from 20 working days (i.e. four weeks), the SMLTP is accepted as OK from 09/24/2015 (Booked Date) if the SMLTP is in a range of 18 to 21 days. These choices are also justifiable from the factory and customer perspective. Considering the four week manufacturing lead time, it is irrelevant whether the promised manufacturing lead time deviates one or two days from the standard. Figure 12 clarifies this.

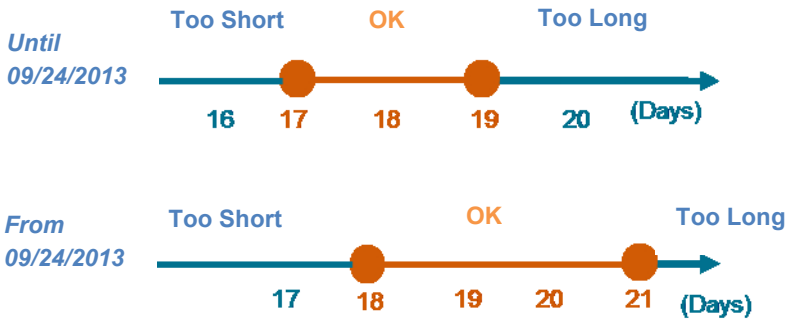

Figure 12. *Large Standard OK-bounds.*

To ease collecting the order lines of a specific FMLTP classification together, a new parameter was derived: the FMLTP promise according to the case company's standards expressed in words – Small Standard, Large Standard or On Request. The previously calculated FMLTPs according to the case company's standards were associated with word definitions. Defining the FMLTP, in addition, by using words was beneficial because some single products had distinctive FMLTPs, such as 5 weeks Large Standard and 1 week Small Standard.

Creation of the comparison table. The purpose of the comparison was to collect all the order lines of a specific product together and display the performance as compared to standard FMLTPs. VLOOKUP functions and pivot tables were used to build the comparison table, of which Appendix C is a screenshot. Figures 13, 14 and 15 presented below are smaller screenshots that exemplify the analysis.

The first columns of the comparison table, as presented in Figure 13 show the basic information of the products. The products are categorized according to manufacturing team, sales volume and sales price range. The next columns reveal the total number of order lines and total sales volume. The last three columns presented in Figure 13 indicate the performance of the FMLTPs. The percentages denote the proportion of orders that are sold with the standard FMLTP (OK) or with an order specific FMLTP (Too Short, Too Long). Orders that fell, due to order quantity, to On Request classification are excluded from these percentages, because they don't have a comparable recommended manufacturing lead time. Nevertheless, On Request orders are included in the Total Order Lines and Total Sales Volume figures.

				All Orders				
Product	**Manufacturing Team**	**Volume Category (High, Medium, Low)**	**Price Category (€/€€/€€€)**	**Total Order Lines**	**Total Sales Volume**	OK % (On Request excluded)	Too Short % (OR excluded)	Too Long % (OR Excluded)
PRODUCT A	IN1	Low	€ €	200	224	88%	5%	8%
PRODUCTS	IN1	Medium	€	375	1807	84%	10%	7%
	IN1	Low	€ €	105	131	83%	3%	14%
	IN1	Medium	€ €	1222	2667	78%	4%	18%
	IN1	Low	€	231	430	77%	3%	20%
	IN1	Medium	€	263	3284	76%	3%	21%
	IN3	Low	€	140	528	75%	4%	22%
	IN1	High	€	1137	7128	74%	4%	22%
	IN3	Medium	€	327	2796	73%	3%	24%
	IN3	Medium	€ €	634	1427	73%	6%	21%
	IN3	Medium	€	741	3008	73%	6%	21%
	IN1	Low	€ €	520	818	73%	9%	19%

Figure 13. *Screenshot of the comparison table: all orders.*

Figure 14 is a screenshot of the Small Standard section of comparison table. The comparison was done based on order lines and sales volume. Columns "% of total order lines" or "% of total sales volume" are proportions of the total order lines of the product. Conversely the columns "Grand total of order lines" and "Grand total of sold products" show the totals of the Small Standard orders. Similarly, the columns "OK %", "Too Long %" and "Too Short%" present the proportions of the Small Standard orders.

For instance Product A, the first product in the table presented in Figure 14 reveals that 99% of the all order lines, in total 197 order lines, are quantities that fell into Small Standard classification. These order lines cover, 94% of the total order volume, that is 210 sold products. Furthermore, 89% of these order lines and 87% of the order volume

are sold exactly according to the case company's Small Standard FMLTP (i.e. 3 working days for that particular product).

Product	Small Standard									
	Order line based					Sales volume based				
	% of total order lines	OK %	Too Short %	Too Long %	Grand total of order lines	% of total sales volume	OK %	Too Short %	Too Long %	Grand total of sold products
PRODUCT A	99%	89%	4%	8%	197	94%	87%	4%	9%	210
PRODUCTS	92%	89%	4%	7%	345	62%	89%	2%	9%	1113
	98%	84%	3%	13%	103	85%	84%	4%	13%	111
	96%	78%	4%	18%	1176	67%	75%	3%	21%	1793
	100%	77%	3%	20%	230	91%	71%	3%	27%	390
	93%	79%	2%	19%	245	22%	76%	1%	23%	736
	96%	75%	3%	22%	135	56%	67%	4%	29%	297
	98%	74%	4%	22%	1118	67%	62%	5%	33%	4786
	82%	74%	2%	25%	269	29%	61%	1%	38%	821
	95%	75%	4%	21%	603	77%	72%	4%	24%	1094
	93%	75%	4%	21%	691	63%	71%	3%	26%	1903
	95%	75%	5%	19%	494	74%	74%	5%	21%	608

Figure 14. *Screenshot of the comparison table: Small Standard.*

Figure 15 presents a screenshot of Large Standard and On Request orders for the same products as Figure 14 presents. The logic of the comparison is similar to the logic explained above for the Small Standard orders. Nonetheless, for On Request orders only the totals and proportion of total orders is presented, since they do not have a standard lead time.

Product	Large Standard										On Request			
	Order Line Based					Sales volume based					Order Line Based		Sales Volume Based	
	% of total order lines	OK %	Too Short %	Too Long %	Grand total of order lines	% of total sales volume	OK %	Too Short %	Too Long %	Grand total of sold products	% of total order lines	Grand total of order lines	% of total volume	Grand total of sold products
PRODUCT A	2%	0%	100%	0%	3	6%	0%	100%	0%	14	0%	0	0%	0
PRODUCTS	7%	14%	82%	4%	28	28%	20%	75%	5%	504	1%	2	11%	190
	2%	0%	0%	100%	2	15%	0%	0%	100%	20	0%	0	0%	0
	2%	62%	21%	17%	29	9%	63%	19%	18%	242	1%	17	24%	632
	0%	100%	0%	0%	1	9%	100%	0%	0%	40	0%	0	0%	0
	5%	23%	31%	46%	13	38%	24%	24%	52%	1248	2%	5	40%	1300
	3%	75%	25%	0%	4	17%	83%	17%	0%	92	1%	1	26%	139
	1%	69%	0%	31%	13	10%	61%	0%	39%	746	1%	6	22%	1596
	16%	72%	9%	19%	53	60%	68%	10%	22%	1681	2%	5	11%	294
	5%	42%	48%	10%	31	23%	57%	34%	9%	333	0%	0	0%	0
	7%	47%	37%	16%	49	33%	52%	33%	15%	993	0%	1	4%	112
	4%	14%	77%	9%	22	13%	19%	69%	12%	110	1%	4	12%	100

Figure 15. *Screenshot of the comparison table: Large Standard and On Request.*

Exclusions and categorization. Products with less than 30 order lines were excluded to avoid bias in making conclusions based on too few samples. Moreover, this exclusion is justified by the objective of the thesis to provide list of products whose FMLTPs should be improved first. The FMLTPs of the products that are ordered more often and produce higher revenues are prioritized to be analyzed and improved first. The products that have only a few orders have also a lower impact to business in terms of winning orders

and market share, creating revenues and costs. Furthermore, Fast Track, 1 day FMLTP, orders are discussed separately in Chapter 4.4, and they are not included in the product comparison table. Fast Track orders are a small minority in the case company, ca. 0.5% of total order lines.

As Figure 13 earlier showed, the comparison table categorizes the products according to manufacturing team, sales volume and sales price. The production is divided to be the responsibility of three manufacturing teams, which are IN1 (Instrument 1), IN2 (Instrument 2) and IN3 (Instrument 3).

Low priced products, "€", cost under 300€. Medium priced products, "€ €", cost 300-1000€ whereas high priced products, "€ € €", cost from 1000€ to around 2000€. The Head of Demand and Supply Chain Management (DSCM) helped to determine the bounds between the price categories. The 300€ boundary was justified so that products are generally of a similar type under the 300€ price. The prices are average sales prices from the fiscal year 2014. Because some products are sold to a system business area and the price of those sales may differ from products sold to external customers, I used a weighted average for prices. I weighted the average sales prices of the system business and the instrument business with their sales volume.

The products were products are sorted similarly to three categories according to their sales volume. Low volume represents products with less than 1000 delivered products, medium volume products cover total volumes ranging from 1000 to 5000 pcs and high volume products equal to products sold over 5000 pcs. The highest volume is approximately 20 000 pcs. The data reveals also that the 14 high-runner products contribute almost 60% of the total sales volume, whereas the 41 low volume products cover only 7 percent of the total volume. Noticeable is, that, in addition, over 60 products were excluded from the analysis because they had under 30 orders within the analysis period. However, all products in the analysis are not fully comparable because the data for some products include a large amount of different configuration options, whereas some products may have only a few options. However, the noticeable amount of products of a very low volume indicates that there might be room to sharpen the product portfolio. Product portfolio management is, however, out of the scope of this thesis. Table 11 presents the categorization and proportion of each category.

Table 11. *Product categorization, products with less than 30 order lines excluded.*

Price	**€**	**€ €**	**€ € €**
# of products	36	38	18
% of products	39 %	41 %	20 %
Volume	**Low**	**Medium**	**High**
# of products	41	37	14
% of products	45 %	40 %	15 %
% of total sales volume	7 %	34 %	59 %

Distribution of SMLTPs and Total Ordered Quantity. Pivot charts were created to visualize the distributions of SMLTPs (sold manufacturing lead time promises) and Total order quantities. While the previously introduced comparison table helps to identify the products and their FMLTPs that did not seem to match with the market requirements, these charts reveal more information about the order behavior. For instance, if the comparison table suggests that the SMLTPs of a particular product are constantly shorter than the standard FMLTP, the chart displaying the distribution of SMLTPs provides insight into how much shorter the SMLTPs typically are. Likewise, the chart of Total ordered quantity distribution visualizes clearly the typical order sizes. Figures 16 and 17 present these charts of an ExampleProduct 1.

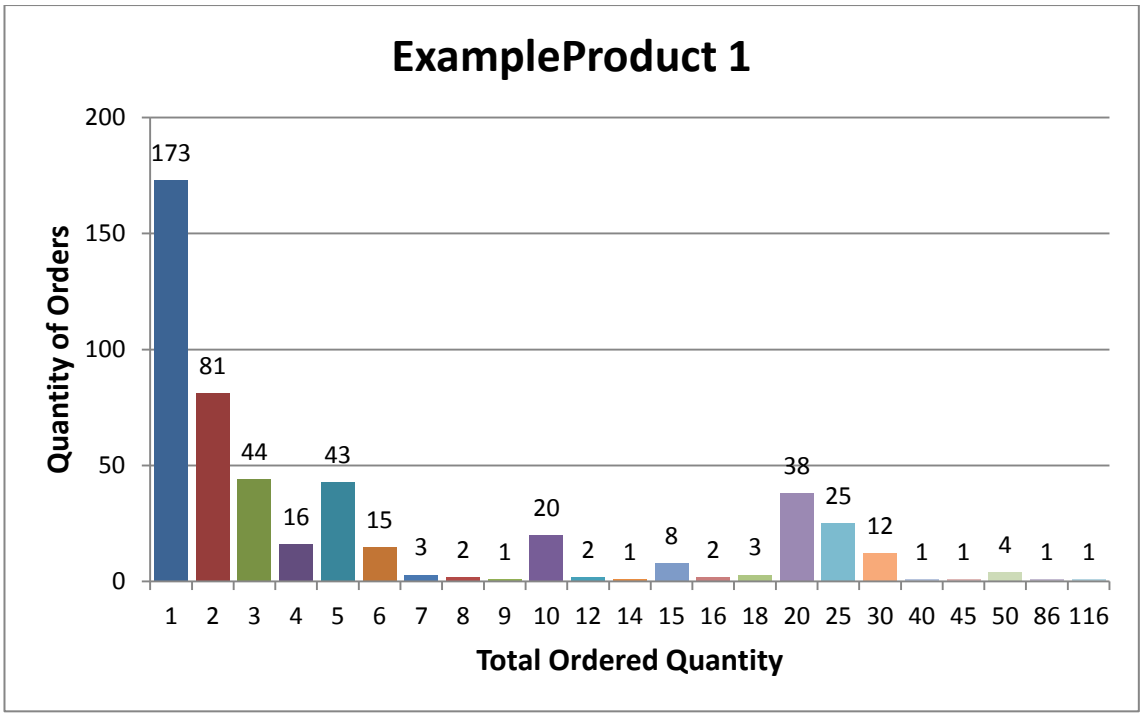

Figure 16. *Example of Total ordered quantity chart.*

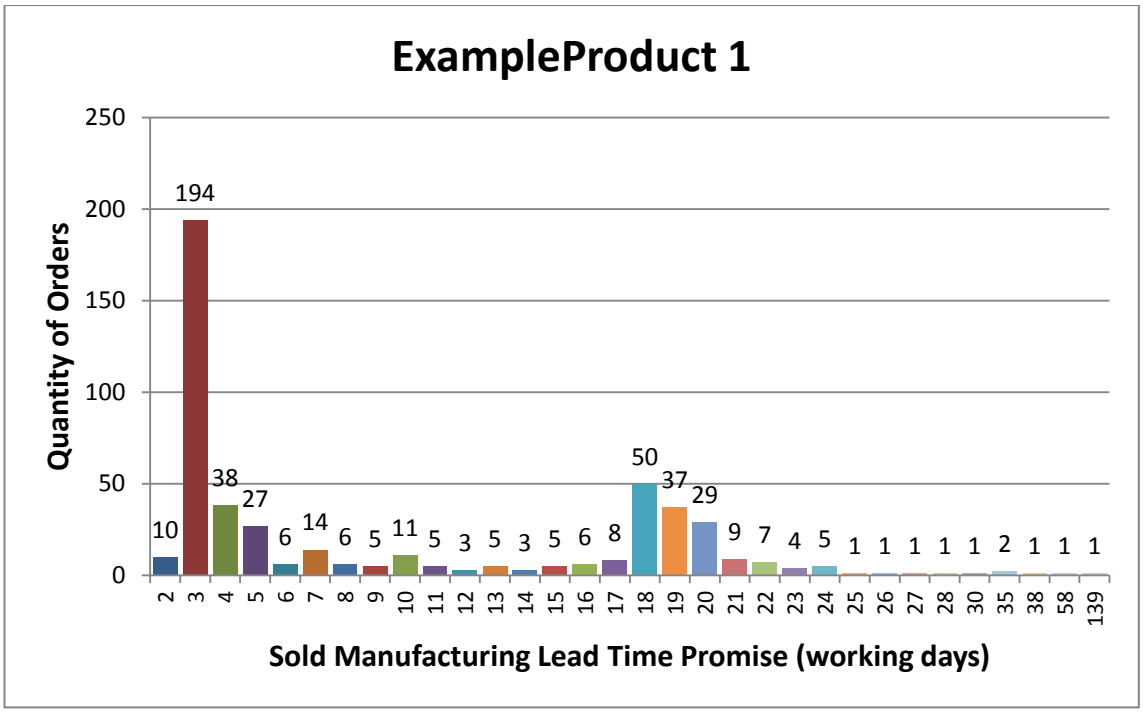

Figure 17. *Example of Sold manufacturing lead time promise chart.*

4.3.3 Validity and Reliability of the Data

Human errors in making of the analysis are probably the most significant source of errors. Errors are possible, since the analysis required a lot of manual data processing and calculation of new parameters. Frequent random tests and manual test calculations were used to verify the quality and correctness of the data. Furthermore, to prevent human errors and to ensure the reliability of the analysis, the analysis was frequently discussed and showed to other colleagues during the process. The Excel functions were showed to them and the logic of the analysis was explained. In addition, after the analysis was ready, the results were presented to the colleagues so that they had the possibility to comment on possible mistakes or issues that should be taken into account.

The basic data do not reveal when temporarily prolonged FMLTPs were in use. This needs to be taken into consideration, because otherwise it would considerably distort the analysis. Therefore, the order lines booked during periods of prolonged FMLTPs were excluded from the analysis. These delivery disruptions are announced and archived in the case company's intranet. These announcements were manually checked and the periods of delivery disruptions were gathered to a excel sheet. Then an Excel VBA (Visual Basic for Applications) script, which indicates the order lines that were booked during the periods of prolonged FMLTPs, was written. Thus, these order lines were simple to exclude from the analysis, which made the analysis more reliable.

A couple of products' FMLTPs had been changed during the time period of analyzed data. These changes were similarly announced as the temporarily prolonged FMLTPs

and archived in intranet. Therefore, the changes were relatively easy to take into account. The FMLTP performance was calculated to each order line with the currently existing FMLTP. If this had not been considered, the data might have indicated that a large proportion of orders were not sold according to FMLTPs, even though they were sold exactly as the FMLTP was at the time of booking the order.

4.4 Conclusions of the Sales Data Analysis

The main purpose of this sales data analysis was to identify the products whose FMLTPs do not meet the market need. Chapter 5.3 presents these products. This chapter discusses other discovered remarks concerning the current state of the FMLTP model.

Distribution between FMLTP classifications. During the two year period from 1st November 2012 to 30th October 2014 the case company had in total over 63 000 order lines for the selected products. This number includes also the products that had less than 30 order lines during that period. The 63 000 order lines represent almost 280 000 delivered products. Table 12 demonstrates how these orders distributed between standard FMLTPs.

Table 12. *Distribution between the FMLTP classifications.*

Fixed Manufacturing Lead Time Promise Tier	% of Sales Order Lines	% of the Total Sales Volume
Small Standard	94%	51%
Large Standard	5%	26%
On Request	1%	23%

Table 12 shows that the amount of Small Standard order lines is as high as 94% whereas Large Standard and On Request class covers merely 5% and 1% of the total order lines. The sales volume based on the situation differs significantly. The Small Standard order lines cover approximately the half of the sales volume, whereas Large Standard class captures one fourth of the sales volume and On Request classification represents over one fifth of the total sales volume. On the one hand, these data confirm that a great majority of the transactions are small orders. On the other hand, the data reveal that Large Standard and On Request orders have clearly high importance to the business as a whole, even though the order line based on these classes are a minority. Large orders are especially important from the net sales' and the market share's point of view.

Split orders. The analysis of order size distribution by product indicates clearly that the bounds of FMLTPs often steer the orders. This is visible as demand peaks at the upper

bounds of the FMLTPs. As the interviewees explained, large orders are in some cases split to smaller orders, which allows the salespersons to promise the order with a shorter manufacturing lead time than it should be according to the standard. Figure 18 shows a clear example of this. The orange column of 139 orders represents orders of 20 pcs, which is the upper bound for Small Standard orders for ExampleProduct 2 This indicates a need to deliver medium to large quantities faster than currently. Chapter 5.3 discusses the need for FMLTP improvement for ExampleProduct 2 and for the other products in further detail.

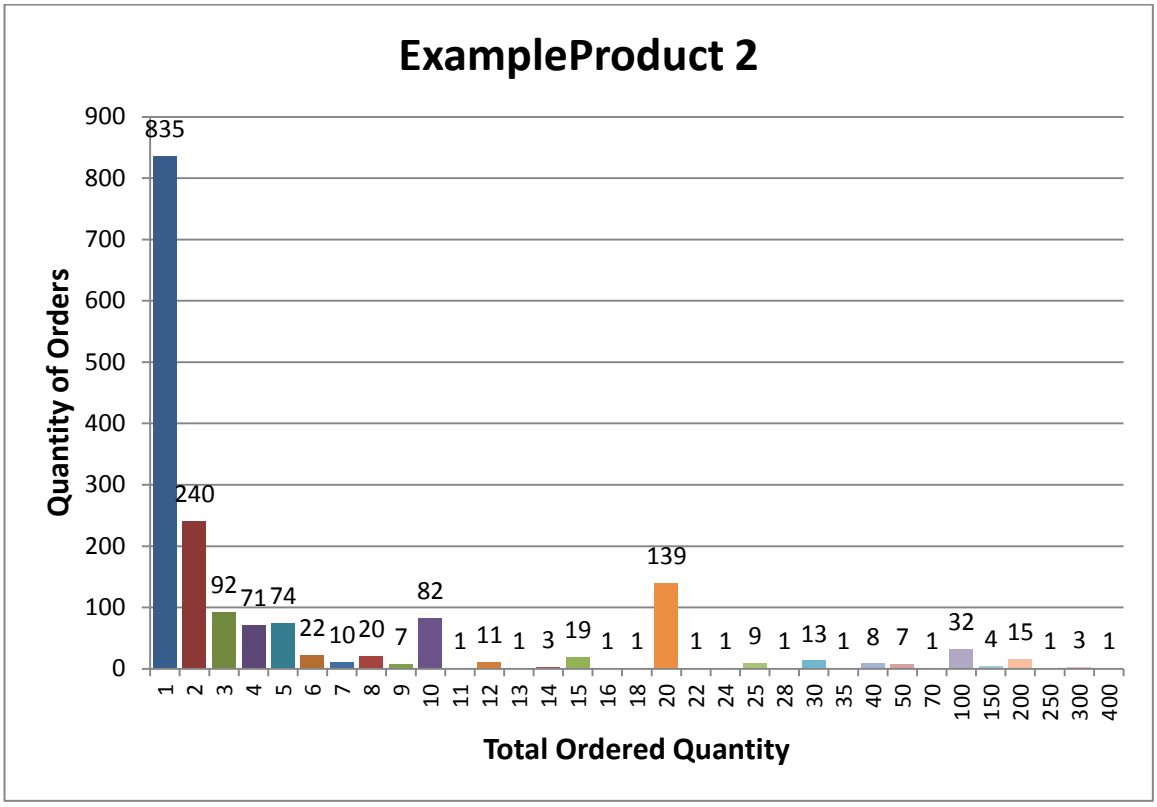

Figure 18. *Example of demand pikes.*

Fast Track. Case company provides a Fast Track (i.e. 1 day FMLTP) option. The data revealed that only 332 orders in total, that is around 0.5% of total orders were Fast Track orders. Of those orders 96 were ProductNameX orders, 48 ProductNameX and 18 were ProductNameY orders, each representing approximately only 1% of the total order lines of these products. In addition to these products, only 5 other products had over 10 Fast Orders during the 2 year period of the analyzed data.

4.5 Delivery Time Benchmark Against Competitors

The case company's CEO stated in the company's internal 2014 quarter 4 interim results info session that competition is getting fiercer all the time. He said that the case company fights the competition by being better when it comes to quality, delivery times, product performance and technology but not by lowering prices. The CEO con-

tinued that "delivery capability was absolutely the key to that [high growth of instrument business] … we needed, also with a short notice, to deliver fairly substantial volumes and hence beat competition in there". The CEO's comments underscore the importance of delivery times to the case company. (Case company 2014b)

The case company has three main competitors whose product mix covers all the instrument market segments in which the case company operates. In the handheld instrument markets one bigger and strong competitor exists. In HVAC (Heating, Ventilation and Air Conditioning) instruments markets several smaller competitors compete against the case company. From industrial or process measurement segment two main competitors are above others. Figure 19 gathers these main competitors together. (Case company 2014a)

Figure 19. *Instrument business competitors (adapted from Case company 2014a).*

All instrument markets. **Kimo** provides a list of their lead times on their websites. Kimo reveals that most of their items are made to order but add that they do, however, carry a stock of selection of certain instruments. Kimo advises the following lead times:

- 5-7 days for portable instruments
- 10 days for data loggers, manometers and pitot tubes
- 14 days for transmitters
- 14 days for repairs and calibration. (Kimo 2015)

Kimo mentions that in case of an urgent need, expedited deliveries are possible or they can possibly loan an instrument whilst the order is fulfilled. According to Kimo, the lead times may be longer during holiday periods in July and December. In addition to lead times, Kimo specifies shipping conditions. According to them "standard shipping is

2-3 day economy courier and next day shipping is available from UPS and costs an extra 15£". Kimo does not specify what they mean with the term lead time. Assumedly, the delivery time experienced by the customer is the lead time plus shipping time. Kimo tells neither how big quantities can be ordered with the above mentioned lead times. Nevertheless, the case company seems to be able to deliver at least small quantities faster than Kimo. (Kimo 2015)

E+E Electronics (later E+E) does not reveal their delivery lead times on their websites. Nonetheless, the company answered to the email enquiry. According to the technical sales department of E+E, the delivery time for the whole product mix is 2-3 weeks, also for bigger quantities. They did not specify how large quantities E+E is able to deliver within the above mentioned delivery time. The case company had recently ordered, via straw person, a carbon dioxide measurement instrument for product technology benchmark purposes. The delivery time was around 2.5 weeks. In addition, another instrument was recently ordered and the delivery time was 19 days. These delivery times match with the answer received from E+E. This indicates that the case company is able to deliver small quantities faster than E+E. On the contrary, E+E may be capable of delivering medium to large sized quantities faster than the case company.

Likewise, **Rotronic** does not reveal their delivery times on their websites and they did not answer to email inquiries. Thus, the only comparison could be made between two instruments that were recently ordered via a straw person. A CO2 (carbon dioxide) instrument was delivered within one week. Another instrument was delivered in 8 working days. This indicates that Rotronic delivers small quantities approximately as fast as the case company. On the other hand, the instrument had a 3-months-old calibration certificate, which indicates that the product was delivered from stock.

Handhelds. A German manufacturer **Testo** is the main competitor in handheld instruments markets. Testo neither reveals their delivery times nor answered to emails. Because the case company had not recently ordered Testo's instruments, comparable data of the delivery times of Testo were not obtainable.

HVAC. According to the interviewees industrial measurement devices for HVAC applications are often more of a commodity type and many competitors sell these instruments off the shelf (see Chapter 4.2). Internet searches verified this. **S+S Regeltechnik** (later S+S) even promises to deliver within 24 hours from placing the order (S+S 2015). S+S states that they have a "generous finished products' stock inventory". They clarify that, in addition to this, they carry a stock of unfinished parts, semi-finished parts and other components, which, combined with their product platform concept, enable the fast deliveries. Likewise, **Thermokon** stocks a variety of standard sensors, whose delivery time is up to one week (Thermokon 2015). According to Thermokon these off the shelf deliveries are often delivered immediately after the receipt of order. Larger quantities and custom designs are available on request. **Veris Industries** (later Veris) answered to

email enquiries in detail. According to the email answers Veris has a finished products' stock of the most popular products. They emphasized that their aim is to ship the same day that the order is received, even though it requires manufacturing. Veris ships their products directly to the customer using standard courier services from DHL, FedEx and UPS. However, Veris Industries gave no information about the quantities they are able to ship within the same day. **SenseAir** is an exception. According to the email answers from them, they do not carry any inventory of finished products. They manufacture to orders and advice a standard delivery time of two weeks. SenseAir added that their distributors "in every country" keep a stock of finished products. MTS manufacturers S+S, Thermokon and Veris are able to deliver at least small quantities faster than the case company.

Industrial and process measurement. Delivery time information of **Michell Instruments** was got from the company's UK Sales and Marketing Manager by email. He explained that Michell has a large and diverse range of products, whose delivery times "vary from less than 1 week to more than 12 weeks for our [Michell's] more complex analyzers". He added that delivery times depend on the quantity but did not give a more detailed answer. Additionally, he told that Michells OTD performance was close to 95% and the average delivery time of Michell Instruments as a company was 3.2 weeks in 2014. Finally, he assumed that "delivery times are broadly similar in our industry [industrial measurement], although for sure Michell do not claim to offer the best delivery times". Probably the case company beats the delivery times of Michell Instruments at least among high end, complex products.

According to the emails from **CS Instruments**, their standard delivery times of the instrument products are two weeks with the exception that "OILcheck and particle counter PC 400" has longer, 4 to 6 weeks, delivery times. CS Instruments exemplified that "within that period of time [2 weeks] my colleagues in the order processing department/shipping department will always manage to dispatch the goods". CS Instruments delivers standard products "without problems" up to 30 to 40 pcs in two weeks. Instruments requiring calibration for gases such as argon, carbon-dioxide and oxygen or instruments with a special measurement range need "a little longer delivery time in larger quantities". However, CS instruments did not specify the quantities requiring longer delivery time for the formerly mentioned instruments. According to this information, the case company is able to deliver small quantities, possibly considerably faster than CS instruments. Nevertheless, CS Instruments may deliver medium to large quantities faster, since the case company's delivery time bumps from 3 days for small quantities to 4 weeks for large quantities.

These results verify the intuitions of the respondents of the interviews. The case company seems to have competitive, possibly superior, delivery times in complex high end products for small quantities. Regarding large quantities, the case company's position against their competitors could not be verified. Among HVAC instruments, the case

company has some pressure from MTS producers who offer even same-day shipping. Nonetheless, it should be noted that the above mentioned delivery times are manufacturer's own delivery times. The case company and their competitors sell products also via distributors who carry a stock and are able to deliver and sell products instantly off the shelf. Thus, one solution to answer to the pressure from MTS manufacturers is to find more distributors who would stock the case company's products and carry the risk of having an inventory.

5. RECOMMENDATIONS FOR THE CASE COMPANY

The purpose of this section is to provide improvement suggestions for the case company's process for managing the FMLTPs as well as to list the products that have the clearest need for FMLTP improvement.

The first chapter aims at providing improvement proposals for NPI (New Product Introduction) process. The aspiration is to ensure better communication and more systematical and comparable FMLTP decisions. After that, the next chapter discusses how to track and evaluate the performance and the need to revise the FMLTPs. The last chapter of this section identifies the products whose FMLTPs have the clearest mismatch with market requirements.

5.1 Creation of FMLTPs for New Products

The semi-structured interviews (Chapter 4.2) revealed that more communication as well as structured and coordinated decisions of the FMLTPs is needed. Subchapter 4.2.3 brought up that FMLTP decision making and rationale interest many different stakeholder groups. However, the decisions are currently poorly communicated and documented. This chapter presents the improvement actions for being able to respond these challenges.

The first Subchapter 5.1.1 provides guidelines for FMLTP decisions. Subchapter 5.1.2 presents actions that were initiated to improve and encourage the communication of the FMLTP decisions.

5.1.1 Document to Support FMLTP Decisions

This chapter presents the factors that should be taken into account in making FMLTP decisions. The factors are based on the interviews (Chapter 4.2) and the findings in Section 3, that is the theoretical background. Especially relevant were the answers summarized in Figure 9 and the factors by Olhager (2003) listed in Table 2.

Currently, at the early phase of the NPI process, at DR2 (Design Review 2) stage, the process contains only a mention that the FMLTPs have to be defined. The case company has no further guidelines for defining the FMLTPs and on which factors the FMLTP decision should be based on. The intention is that a document based on the factors as

presented in this chapter will be done and added to the case company's NPI process to support rational decision making.

On the one hand, the purpose of the document is to standardize the FMLTP definition process and to ensure justified decisions. The document acts as a guideline for NPI project team and encourages taking the relevant factors into account. On the other hand, the intention is to make the FMLTP decisions more transparent and comparable.

After the document is implemented in the NPI process, the justifications according to the listed factors will be documented and uploaded into the case company's PDM (Product Data Management) system. Later on, whoever from the case company can check what the assumptions have been at the time of deciding the FMLTPs and compare these assumptions to the current state. The company can also start to track how well the NPI project teams manage to evaluate the market conditions. If there appears to be consistent failures in estimating the market behavior, which have led to FMLTPs that do not meet the market requirements, the case company may justifiably decide to put effort on improving the quality of the market studies.

Next, the factors are discussed. These factors are divided into three groups: customer need, product and supply chain adopting the division presented as in Figure 9.

Customer need

Targeted customer base is one of the key factors to consider. The NPI project team should consider whether the customers are from the stray markets or if some major key customers to whom the product is targeted exist – or, whether the market is some combination of these alternatives. If the major customers are known beforehand, the demand is easier to predict. The case company can obtain reliable forecasts of the estimated demand straight from these customers.

The delivery time requirement of the customers is a highly important factor to recognize. If key customers exist and are recognized, customer interviews can be conducted to assess their need regarding the delivery time. In stray markets, there are abundant potential customers and the customer requirement for the delivery time is more difficult to assess. In that case, the delivery times of possible competing competitors' products or other comparable products give guidance for suitable FMLTPs.

The delivery times of possible competing products available on the market should be considered likewise. Understanding one's own position regarding the delivery time as compared to those of the competitors is important to acknowledge. This indicates whether the company can make the delivery time an effective sales argument and competitive advantage or not.

Estimated demand volume is one of the key inputs to a company's production. It determines what are the production capability and capacity needed to be able to fulfill the market demand. Moreover, a demand volume estimation is one of the most important inputs for the sourcing department as they negotiate contracts with suppliers. The demand volume should be estimated at least on monthly basis. Demand volume should be estimated for the ramp-up phase as well as for the mature stage as the demand is expected to stabilize. The expected demand after the ramp-up phase is the key target for building production capability.

Estimated demand volatility refers to how fluctuated, that is, characterized by peaks, the demand is expected to be. There is a significant difference between receiving small orders constantly and large orders occasionally even if the aggregate, e.g. the annual volume, was equal. According to the Head of Sourcing, if demand volatility was justifiably estimated, the sourcing department would be able to do flexibility agreements with the suppliers. Flexibility agreement refers here to a supplier's commitment to deliver a certain amount with the agreed range each month, e.g. 1000 pcs ± 30% according to the actual demand.

Product

The factors listed in the product category give guidance of the possible FMLTPs. These factors primarily base on comparing the new product to existing similar or representing products.

Configurability, customization, tailoring: As a rule of thumb, the customers accept longer delivery times for highly configured or customized products. In general, for simpler low configurable products short delivery times are expected also for substantially larger quantities.

Sales price: as the respondents stated, customers expect to receive cheaper and simpler products faster than more expensive and complex products.

Brand new or replacement product?: If the product is a replacement product, that is a new generation version, the FMLTPs of the old generation product give an idea about the suitable FMLTPs. Likewise, the FMLTPs of possible comparable products give guidance of the possible FMLTPs. Naturally, this should be rather an indicative than decisive factor, because possible misestimates and mismatches with the market need should not be copied and multiplied.

Supply Chain

Production lead time: Production lead time is a limiting factor for the FMLTPs. The production lead time should be adjusted to the customers' delivery lead time require-

ments, the estimated demand volume, and the capacity requirement derived from those factors.

Bottleneck operation and other limiting or exceptionally time demanding phases. Production phases that require a long lead time need to be identified. These phases include the bottleneck and other critical, time demanding production phases. Typically, in the case company's production, these are calibration or testing.

Availability and lead times of components and subassemblies: suppliers' ability to supply materials, components or subassemblies is usually one of the most substantial factors limiting the case company's delivery capability.

Storing and buffers refer to decisions regarding inventory levels and WIP buffers, which are maintained to ensure the desired FMLTP capability. The former factor, availability and lead times of components and subassemblies, is tightly interconnected with the storing and buffer decisions.

Cost of maintaining required inventory levels needs to be considered. It is highly important to take the cost aspect into account to understand what the desired FMLTPs' capability costs to maintain.

5.1.2 Communication of FMLTP Decisions

The FMLTP document introduced in the previous chapter responses to the need to standardize and support making justified FMLTP decisions. Another key issue the respondents brought up was lack of communication and transparency in the process of defining the FMLTPs. There is a clear need to encourage and guide the NPI project teams to share the justifications and the planned FMLTPs as early as possible. As mentioned, the FMLTP document will be stored into the PDM, but it is not enough. It is unlikely that other stakeholders than the NPI project team would check these documents self-imposed.

Therefore, the FMLTPs are intended to be added to the case company's Launch Plan immediately, as the project team has decided on the FMLTPs in DR2. The Launch Plan is a document that is created and reviewed by sales, marketing and business area directors. Adding FMLTPs to the Launch Plan ensures that the planned FMLTPs are reviewed by sales and business areas in the early phase of the NPI project. If someone disagrees with the suitability of the planned FMLTPs, changes in the FMLTPs are still possible to make.

The FMLTPs in the Launch Plan and the archived FMLTP checklist document should significantly add transparency to the FMLTP process. The LCM Manager has already at the time of writing this thesis, requested this update to be added to the Launch Plan. Parameters of the new products are already stored to several documents in the NPI pro-

cess. Therefore, it should be evaluated whether the content proposed to the FMLTP checklist document, could be integrated to some existing document to avoid increasing any unnecessary complexity in the form of an abundant number of documents and instructions in different locations of the process.

5.2 Revision of the Existing FMLTPs

Respondents expressed a clear need to review and track the performance of the FMLTPs systematically. This chapter proposes concrete indicators and follow up actions. The indicators and other actions are divided into four groups adapting the four groups formed after the interpreted responses in Subchapter 4.2.2. These metrics should indicate the need for revising the FMLTPs. Likewise, they should imply how well the NPI project team was able to estimate the market need and whether the production capabilities have changed.

These groups are demand changes, meeting the market need, product life cycle and changes in supply chain capability. The following subchapters discuss the proposed metrics in detail.

5.2.1 Demand Changes

The respondents highlighted the importance of tracking changes in the market demand. The following metrics indicate the actual demand and the demand volatility. Furthermore, these metrics visualize the demand and the changes over time when they are compared with the earlier years or with the estimates of the NPI project team.

1) Average order size (pcs) and standard deviation
2) Total actual and average weekly demand (sales) volume and standard deviation

In addition, a RSD (relative standard deviation) is useful. The RSD expresses quickly how volatile the demand relatively has been and thus, makes the volatilities more comparable.

The average order size and frequency of orders is calculated as arithmetic mean. The arithmetic mean is often referred to only as a mean. The mean, usually denoted by $\bar{x}$, is calculated with formula 3:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n}(x_1 + x_2 + \cdots + x_n) \quad , \tag{3}$$

where $x_1, x_2, \ldots, x_n$ are the observation values, $i = 1$ and n is number of observations (Andersson 2006, p.52).

Standard deviation, denoted by s is calculated with formula 4:

$$s = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad , \tag{4}$$

where x_i is observation, $\bar{x}$ is the arithmetic mean and n is the number of observations (Andersson 2006, p.52).

Relative standard deviation expressed in percentages is calculated with formula 5:

$$\%RSD = 100\frac{s}{\bar{x}} \quad , \tag{5}$$

where s is the standard deviation and $\bar{x}$ is the arithmetic mean.

Example. Table 13 presents the average order sizes and the standard deviation of the average order sizes for three products whose order behavior differs highly from each other. Table 14 presents the averages and the standard deviation of weekly demand. Figure 20 visualizes the total weekly demand for those three products.

Table 13. *Example: average order size and standard deviation 11/2012-10/2014.*

Metric	Product 1	Product 2	Product 3
Average order size	2.24	1.22	9.9
St. dev. of order size	4.36	0.65	36.7
RSD of order size	195%	53%	370%

Tables 13 and 14 demonstrate the nature of the demand of the case company's products. The order sizes and the weekly demand may fluctuate from moderate relative fluctuation, as for Product 1 and Product 2, to very significant, as for Product 3. Clearly, the FMLTPs are the easier to match the smaller the order size volatility is. The order size fluctuation reflects also the standard deviation of the weekly demand, which is presented in Table 14.

Table 14. *Example: average weekly demand and standard deviation 2014.*

Metric	Product 1	Product 2	Product 3
Average weekly demand	199.1	21.2	56.9
St. dev. of weekly demand	55.1	7.45	82.7
RSD of weekly demand	28%	35%	145%

Figure 20 visualizes this fluctuation. Obviously, supply chain capability and the FMLTPs are much easier to plan and maintain for products whose relative standard deviation of the weekly demand are low (like Product 1 and Product 2) than for products like Product 3 that have a very fluctuating and unpredictable demand.

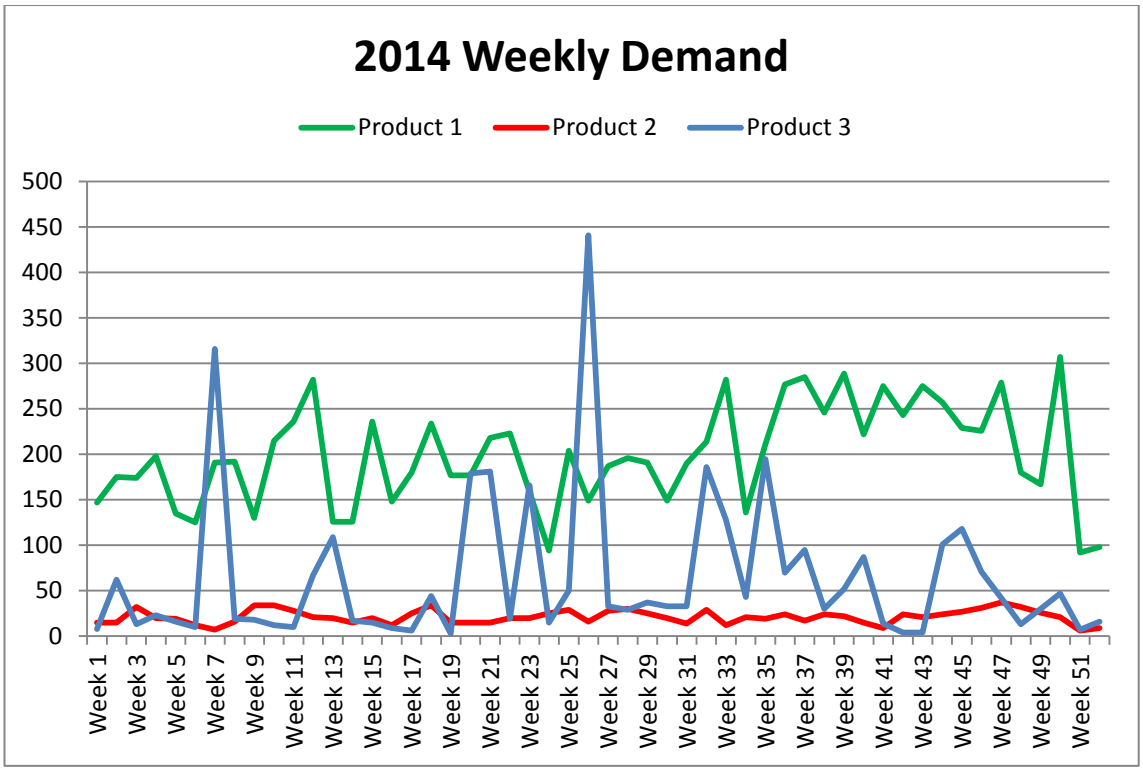

Figure 20. *Weekly demand fluctuation example.*

The needed data are obtainable from the ERP system or the case company's BI (Business Intelligence) software. Thus an automated analysis is relatively easy to establish. The DSCM department should take responsibility for tracking these metrics. As the respondents suggested, regular reviewing and analysis of the indicators and analyses introduced in this and in the following subchapter could be a good starting point.

5.2.2 Meeting the Market Need

The changed market demand reflects the FMLTPs ability to match customer requirements. The sales data analysis introduced in Chapters 4.3 and 4.4 (improvement proposals in Chapter 5.3) provides an easy and a quick indication how well the predefined FMLTPs meet the market requirements. An automated analysis is now easier to build as the logic is clear. Nonetheless, the sales data analysis reveals the need for faster deliveries only when expedited delivery has been allowed by production planners.

The case company has aptly started to collect and archive customer wishes for shorter delivery time than the company has been able to provide. The case company has advised the salespersons to fill the customer's requested ship date into the Request Date field in the ERP system, if there appears to be "a large gap" between customer expectations and the case company's FMLTPs. (Case company 2014c)

These data allow that for each product 1) an absolute amount of customer requests and 2) a relative amount (percentage of the total orders) of customer requests can be tracked. This data should be interpreted carefully for two reasons.

Firstly, the definition of a "large gap" between a customer request and the available FMLTP may differ depending on the personal views of each salesperson. For instance, one salesperson may consider 5 days as a large gap, while another salesperson may consider even 1 or 2 days as large gap, which leads to biased data. Secondly, it is noteworthy that these data contain only the realized sales orders – in other words, the orders when a customer has eventually accepted a longer delivery time than requested. If a customer rejects the bid, the requested date is not documented. Nevertheless, as long as the probable bias is acknowledged, the Request Date data may a be useful, complementary indicator for FMLTP revision.

The sales data analysis presented in Section 4 led to an easy and prompt identification of the products causing the most of the additional work for production planners and sales persons, because of the mismatch with market requirement. The Request Date data helps to identify a cumulative amount of delivery time expedition requests that are not visible in the sales data analysis. In an ideal state, all orders would be sold exactly according to or with longer FMLTPs without any expedition requests. The DSCM department is the natural party to track also these metrics.

5.2.3 Product Life Cycle

The respondents considered (Subchapter 4.2.2) product life cycle related actions to have an impact on the FMLTPs. Basically, during the ramp-up and ramp-down stages of the product life cycle, the FMLTPs should be taken into more thorough consideration. The Product Manager and the LCM department should take responsibility for these actions.

During the ramp-up stage the FMLTPs should be adjusted to the realized demand. The actual demand should be compared to the FMLTPs after predefined periods of time. The respondents proposed that these review points could be, for instance, 6 months and 12 months after the product launch. This review should be based on the analyses and indicators as presented in the previous chapters, although during this early stage, considerable attention should still be paid to the updated demand forecasts.

During the ramp down stage, removing or prolonging the FMLTPs de-emphasizes the product to salespersons and directs sales to a new generation replacement product or other alternative models. Fast Track and Small Standard classification could be removed completely and quantities provided in Large Standard could be reduced. This would enable the company to reduce the inventory levels already during the ramp down stage, which results in cost savings.

5.2.4 Changes in Supply Chain Capability

Changes in the supply chain capability have an immediate impact on the case company's ability to deliver on time and according to the FMLTPs. Therefore, it is extremely important to measure and follow the supply chain capability. Temporary disruptions in the supply chain capability, and, therefore, the temporarily prolonged FMLTPs are communicated with Infomails and the FMLTPs are changed in the ERP system. The standard FMLTPs are restored as the delivery disruption is resolved. Permanent and significant changes in the supply chain capability or changes that are not wanted to be fixed for some reason require a permanent change of the FMLTPs. Table 15 gathers the events and indicators which could be tracked as well as the responsible departments.

Table 15. *Metrics and the responsible department.*

Event that triggers FMLTP revision	Indicator	Responsible
New production phase that slows production lead time	Production lead time	Factory
Significantly reduced production lead time / improved production capacity	Production lead time	Factory
Significant material availability changes	Supplier OTD	Sourcing / Purchasing
Supplier's production & testing capacity changes	Supplier production lead time	Sourcing / Purchasing

These events require mainly reactive actions. However, for instance, supplier OTD might be an indicator of a possible trend in a supplier's supply capability. These indicators are already tracked. Therefore, the data that are available have to be actively utilized in the FMLTP decisions as well.

5.3 Proposal of Improved FMLTPs

This chapter presents the products that were identified to have the most significant mismatch with the market need. The case company should consider revising these FMLTPs. These revision suggestions are based on the sales data analysis that Chapters 4.3 and 4.4 describe. The case company's instrument factory is divided into three manufacturing teams named IN1 (Instrument 1), IN2 (Instrument 2) and IN3 (Instrument 3). Improvement suggestions are presented following the same division.

The sales data analysis revealed, for instance, the following aspects, which were examined to find out the products that need FMLTP revision:

- The relative and absolute amount of orders sold with the standard FMLTPs (Small Standard, Medium Standard, Large Standard) as well as the amount of orders sold with a shorter or longer manufacturing lead time than with the standard FMLTP should have been sold.
- The relative and absolute amount of On Request orders.
- Order size (quantity) distribution.
- Typical order sizes.

In addition, the following aspects were considered as the proposals were formed:

- the existing FMLTPs,
- the FMLTPs of comparable products and,
- the customer base regarding whether products are sold to individual customers or to systems and,
- discussions and interviews with the case company's employees.

A representative example of the logic and a detailed reasoning behind the suggestions is presented next. After the examples, improvement suggestions for other products are presented in Tables 13, 14 and 15. These products are only listed and the main reasons why the current FMLTPs need revision are mentioned.

Example. ExampleProduct 3 is a good example of a product whose FMLTPs do not meet the market requirements. This causes extra work to production planners and sales persons. The current FMLTPs of ExampleProduct 3 are

- Small Standard: 1-6 pcs/3 days
- Large Standard 6-15 pcs/4 weeks
- On Request: 16 or more pcs

Figure 21 presents how the ordered quantities are distributed. This implies that the FMLTPs cover a great majority of orders. ExampleProduct 3 has only 11 (1+1+9) On Request orders as compared to 363 single unit orders.

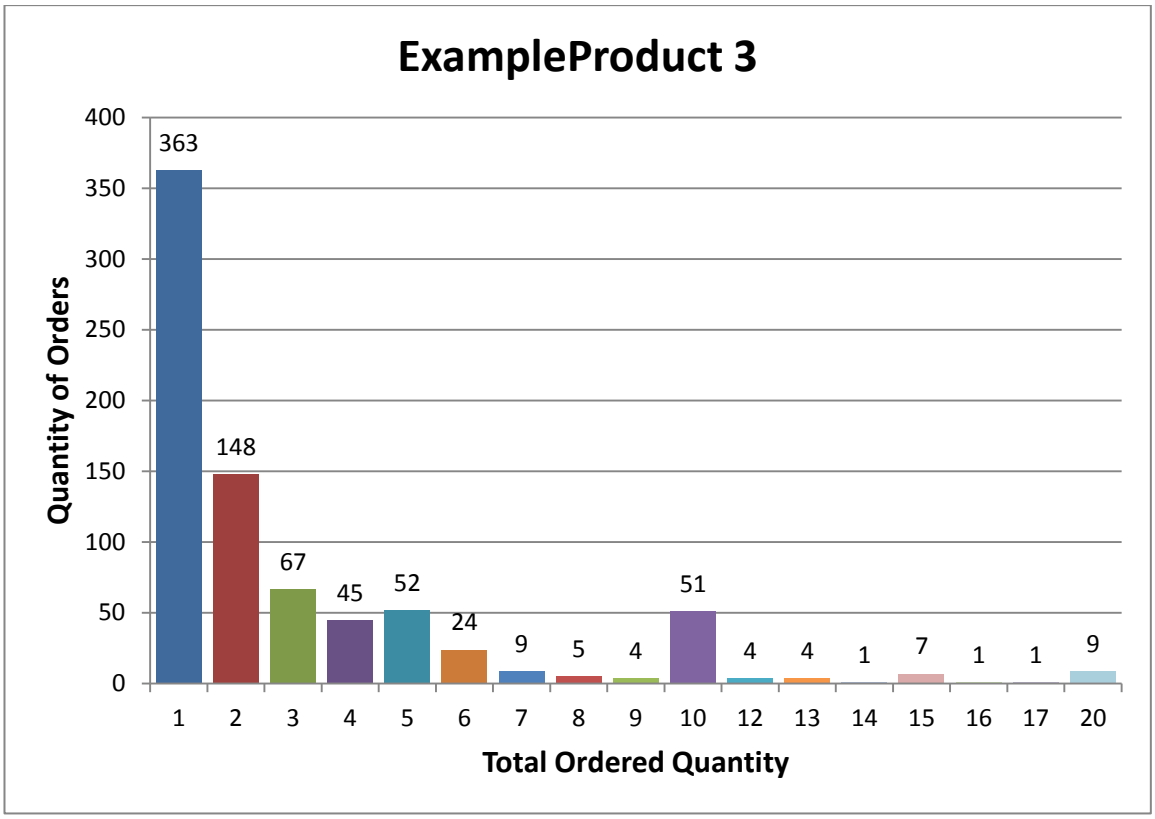

Figure 21. *ExampleProduct 3 Order quantity distribution.*

However, the screenshots from the sales data analysis in Figure 22, that is presented in the next page, reveal more information. The following notifications can be done

- A clear demand for the three day FMLTP. Nevertheless, it is noteworthy that approximately half of the Small Standard FMLTPs are sold with a longer manufacturing lead time than the standard is.
- Only 1% of orders fall into On Request classification, which is positive.
- Over 50% of Large Standard (6 to 15 pcs) orders are expedited deliveries.

Product	Small Standard									
	Order line based					Sales volume based				
	% of total order lines	OK %	Too Short %	Too Long %	Grand total of order lines	% of total sales volume	OK %	Too Short %	Too Long %	Grand total of sold products
ExampleProduct 3	88%	50%	2%	48%	698	57%	44%	2%	54%	1438

Product	Large Standard										On Request			
	Order Line Based					Sales volume based					Order Line Based		Sales Volume Based	
	% of total order lines	OK %	Too Short %	Too Long %	Grand total of order lines	% of total sales volume	OK %	Too Short %	Too Long %	Grand total of sold products	% of total order lines	Grand total of order lines	% of total volume	Grand total of sold products
ExampleProduct 3	11%	29%	58%	13%	86	35%	31%	56%	14%	874	1%	11	8%	213

Figure 22. *ExampleProduct 3 Sold manufacturing lead time promises.*

The large proportion of expedited deliveries, the Too Short category in Large Standard indicates a clear need to deliver small to medium quantities faster than currently. Further analysis revealed that a majority of 10 pcs orders, which are seen as a demand pike in Figure 21, are expedited – in detail, 36 out of the 51 orders were expedited.

This indicates a clear market demand for small to medium orders delivered with longer than 3 days but shorter than 4 weeks delivery time. Expedited Large Standard orders are similar to On Request orders from the production planning and the sales' point of views. Thus, Medium Standard classification is justifiably needed and would reduce the work load of the the production planning and expedite and simplify the bidding process.

As conclusion, the FMLTPs that would meet the market requirements better and reduce the workload of the production planners could be

- Small Standard: 1-5 pcs/3 days
- Medium Standard: 6-10 pcs/2 weeks
- Large Standard: 10-15 pcs/4 weeks
- On Request: 16 or more.

IN1 manufacturing team produces data loggers among other products. The analysis implied a clear need to revise the FMLTPs of data loggers. However, as mentioned in Subchapter 4.2.4 the case company had a project that aimed at improving the FMLTPs of data loggers during writing this thesis. These FMLTPs are already improved at the time of writing this section. Therefore, improvement proposals concentrate on other products.

Characteristic of many products of IN1 team is a very low usage of Large Standard classification. Figure 23 shows IN1 products that have the smallest proportion of order lines Large Standard orders and 0% (rounded) of On Request orders. In general, these

products, have also a substantial amount of expedited Large Standard orders. This indicates a need for shortened Large Standard or for introduction of Medium Standard.

	Large Standard										On Request			
	Order Line Based					Sales volume based					Order Line Based		Sales Volume Based	
Product	% of total order lines	OK %	Too Short %	Too Long %	Grand total of order lines	% of total sales volume	OK %	Too Short %	Too Long %	Grand total of sold products	% of total order lines	Grand total of order lines	% of total volume	Grand total of sold products
PRODUCTS	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	1	4%	24
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	1	5%	27
	0%	#N/A	#N/A	#N/A	0	0%	#N/A	#N/A	#N/A	0	0%	0	0%	0
	0%	100%	0%	0%	1	9%	100%	0%	0%	40	0%	0	0%	0
	1%	0%	100%	0%	1	26%	0%	100%	0%	50	0%	0	0%	0
	2%	0%	100%	0%	3	6%	0%	100%	0%	14	0%	0	0%	0
	2%	0%	0%	100%	2	15%	0%	0%	100%	20	0%	0	0%	0
	2%	50%	50%	0%	4	23%	50%	50%	0%	160	0%	0	0%	0
	3%	50%	50%	0%	2	30%	50%	50%	0%	100	0%	0	0%	0
	3%	29%	43%	29%	7	19%	37%	35%	28%	127	0%	0	0%	0

Figure 23. *Screenshot from the data analysis: low usage of Large Standard and On Request classification.*

All in all, excluding the data logger products, the FMLTPs of the products of IN1 team seemed to meet the market requirements better than the products of IN2 and IN3 teams. Table 16 summarizes the improvement need for the FMLTPs

Table 16. *IN1 team: products that have the greatest need for FMLTP improvement.*

Product	Improvement suggestions	Main Reasons
ProductName	Medium Standard should be added: e.g. 15-30 units. Large Standard should cover more units, possibly up to 100 units.	• A Lot of split orders (to 20 pcs) • Low usage of current Large Standard (2% of order lines) • 53% of sales volume (64 order lines, 4% of order lines) On Request orders
Several products (see Figure 23)	Large Standard FMLTP should be shorter or Medium Standard should be considered.	• A low need for the current Large Standard and no or only single On Request orders • A significant amount of Large Standard orders sold with shorter manufacturing lead time than the standard FMLTP
ProductName	Large Standard should be shorter	• 82% of Large Standard order lines sold with a shorter manufacturing lead time than the standard FMLTP • Small Standard matches with the market demand very well

IN2 manufacturing team. ProductX had delivery disruptions and prolonged FMLTPs approximately 14 months out of the 24 months in the analysis including the whole year of 2014. Thus, the case company should keep the focus on resolving these supply chain capability problems and then, as new, more recent data are available justified evaluation about the need for improvement of the FMLTPs of ProductX can be done. Table 17 lists the products of the IN2 team that have the greatest need for FMLTP improvement. In addition to products listed in the table, Medium Standard should be considered to be introduced to most of the products of the IN2 team.

Table 17. *IN2 team: products that have the greatest need for FMLTP improvement.*

Product	Improvement suggestions	Main Reasons
ProductName	Medium Standard needed and Large Standard should cover more units	• 74% of sales volume (19% of order lines) is On Request orders • Only 18% of Small and Large Standard orders sold with the standard manufacturing lead time, which indicates that the current FMLTPs do not meet the market requirements
ProductName	No need to offer 6-50 pcs Large Standard with the current demand. Remove or shorten Large Standard significantly and reduce the amounts: e.g. 6-15 pcs/2 weeks	• Only one Large Standard order (6 pcs order) and no single On Request order.
5 Products	Introduce Medium Standard	• 35% to 58% of Large Standard order lines sold with a shorter manufacturing lead time than the standard.
ProductName	Introduce Medium Standard and/or Large Standard could be with significantly fewer units and shorter lead time: e.g 1-6 pcs/3 days, 7-20 pcs/2 weeks, 21+ pcs On Request.	• No need to offer up to 40 pcs Large Standard as currently is offered, because only 1 over 20 pcs Large Standard order.

IN3 manufacturing team. For wind products the data analysis shows a bit misleadingly that 55% to 92% of Small Standard orders are sold with a longer delivery time than the standard is. The main reason for this is that in many cases the wind products go to the system integration to the system business area. These internal orders are known early and booked into the ERP system early on as well, which should be taken into account.

Table 18. *IN3 team: products that have the greatest need for FMLTP improvement.*

Product	Improvement suggestions	Main Reasons
3 Products	Medium Standard needed On Request orders would be reduced notably if Large Standard covered even ten pcs more (up to 30 pcs) especially for ProductName and ProductName.	• On average ca. 25% percent of Large Standard orders sold with a shorter manufacturing lead time than the standard.
2 Products	Large Standard could be shorter and with fewer units: e.g. up to 15 pcs.	• No On Request orders • The largest order of ProductNameX is 15 pcs and of ProductNameY 10 pcs. A significant amount of Large Standard orders sold with an expedited manufacturing lead time
2 Products	Medium Standard needed Large Standard should cover more pcs	• A low demand for 3 day classification • A significant amount of Large Standard orders sold with a shorter manufacturing lead time than the standard FMLTP • Over half of the sales volumes is On Request orders
ProductName	Medium Standard or more pcs to Small Standard: could be similar as Small Standard of comparable products (3 Products): 1-5 pcs/ 3days	• Currently 1-2 pcs in Small Standard • 68% of Large Standard (3-10 pcs) orders sold with a faster FMLTP than the standard
3 Products	Medium Standard needed	• A significant amount of Large Standard orders sold with a shorter manufacturing lead time than the standard FMLTP

6. CONCLUSIONS

The case company's FMLTP model has indisputable advantages as well as disadvantages. The clearest advantage of the model is the simplification of daily operations as long as the FMLTPs address the customer requirements. The rigidness of the FMLTP classification was seen as a disadvantage. The strict classification causes wasted time and extra work when flexibility needs to be accommodated. Secondly, the respondents brought up the need for encouraging and ensuring the communication of the FMLTPs, supporting FMLTP decisions in NPI projects, as well as defining when and how the FMLTPs should be reviewed and revised. Furthermore, a noticeable weakness of the FMLTP model is that it is non-integrable to ERP processes as compared to, for instance, ATP and AATP solutions that are integrated to ERP system.

The literature review examined alternative delivery time promising methods. An AATP (Advanced Available-to-Promise) solution based on supply chain resources could be a possible alternative for the case company's order promising. The AATP solution would ensure more reliable due date quoting, as well as reduce the inefficiencies caused by manual capacity checks and redundant communication between the sales and the production planning when the customer request differs from the FMLTP. AATP implementation requires solving some challenges like how to model the case company's complex supply chain and manufacturing resources allocation accurately. However, as the benefits obtainable by AATP implementation are remarkable, the case company should conduct further research on AATP solutions and aim at AATP implementation.

The literature review revealed also the importance of delivery time in competition. Delivery time is one of the key competitive advantages for ATO and MTO manufacturers and a part of product and service quality. Superior delivery time and reliability are important factors ensuring higher profit margins, especially, in case the product quality exceeds the customer's requirements. Thus, the case company should keep strong focus on improving delivery times and delivery reliability.

Regarding to the case company's position in delivery time competition, the benchmark study revealed that the case company's delivery times are in general competitive. The best situation regarding the case company's delivery times against its competitors is among small orders of high-quality configurable products. The case company's three day FMLTP seems to be superior as compared to most competitors in this category and even the strongest competitors seem not to be able to deliver faster. However, the competitive position could not be verified among larger quantities. Indications of this are that some competitors may offer shorter delivery times for larger quantities than the

case company. In addition, amongst simpler and less configurable products, some competitors manufacture to stock, which enables same day deliveries. Hence, in these categories the case company has a pressure to shorten the delivery times or to find more distributors who would carry the stock. Surprisingly, the case company did not have a good knowledge about its position in the competition regarding delivery times. The respondents and the CEO of the case company estimated that competition is becoming stricter and stricter also in terms of delivery times. Thus, it would be increasingly important to maintain a better understanding about the competitors' delivery times. An easy first step to gather these data would be to start documenting the delivery times of the competitors' products ordered for testing, and benchmarking. Currently, these data are not systemically stored.

An extensive sales data analysis was done to enable data based recommendations for products whose FMLTPs fail to meet the market requirements. The viewpoint and idea of reviewing the performance of the FMLTPs was new for the case company and the data analysis was created from scratch. The created data analysis turned out to be highly useful. The analysis revealed very valuable information and justified recommendations for those products having the most urgent need for FMLTP improvement were done. Actually, these results are a part of the case company's strategic OPS Execution Plan 2015. One target of the execution plan is to optimize end-to-end supply chains for selected products and product families. The products identified in this thesis provide input for the supply chain optimization project. Supply chain optimization is often requisite for FMLTP improvement.

A general finding of the data-analysis was that several products would need Medium Standard FMLTP. Introducing Medium Standard is supposed to reduce the significantly high amount of Large Standard expedition request clearly. It could, in some cases, reduce the amount of Small Standard orders too. This will lead to easier production planning and steering as the production is easier to level. In any case, the improvements can be done for the products that evidently cause loads of non-value-add work. Improving the FMLTPs of the identified products should result in better addressed market needs, which in turn should affect customer satisfaction, resulting more won orders and thus, eventually higher profits.

The data analysis was done with a static data set but as the logic and the structure were created, the analysis should be relatively easy to automate to track up-to-date data. In addition, the outcome is scalable. Even though the analysis was done with the products of the instrument business area, a similar analysis can be used to analyze the performance of the FMLTPs of system business area.

Process related improvements to respond to the deficiencies of the FMLTP model were identified in the interviews. The NPI process does not currently define how to make FMLTP decisions. To aid and standardize the FMLTP decisions, the most important

factors to be considered in the FMLTP decision making were listed. The next actions will be to construct a document according to the factors listed, which will be added to the NPI process. Documenting estimates of the listed factors will ensure that the NPI project team members will take the important aspects into account when deciding FMLTPs. Additionally, this will enable the case company to track down how well the project teams are able to estimate the market need. The presented idea of the relevant factors could be developed further. In addition to just listing the factors that should be taken into account, more detailed instructions or even formulae on how the exact quantities and bounds for the FMLTPs should be determined according to the answers on the listed factors could be established. Nonetheless, even adding the proposed list of factors to the NPI process and requiring estimates to the factors is a big leap towards more standardized and justified FMLTP decisions.

To encourage the communication of the FMLTP decisions, in addition to the document, the proposed FMLTPs are going to be added to the case company's Launch Plan in the early stage of NPI process. The Launch Plan is reviewed by business functions and sales. Thus, if somebody disagrees with the intended FMLTPs, the decisions can be discussed and the possibility for making changes to the intended FMLTPs before the whole supply chain capability is designed and built still exists.

Lastly, this thesis provided recommendations on how to track FMLTP performance and when to initiate the FMLTP revisions. Regular reviews of FMLTP performance are extremely important in ensuring that the FMLTPs still match with the market needs and the supply chain capabilities. The time wasted in handling expedited order requests and On Request orders should be reduced. Therefore, a certain amount of time should definitely be invested in FMLTP performance tracking. With active and regular tracking, the case company would be able to proactively minimize the wasted time of the production planners and ensure more efficient sales process. The next actions regarding to this are to assign the responsible parties for tracking the presented indicators and events for certain departments or persons. Accordingly, further work is needed to establish a concrete process and actions of escalating the FMLTP revision process, at the time, when the need to revise the FMLTPs is notified.

REFERENCES

Alemany, M.M.E., Lario, F-C., Ortiz, A. & Gómez, F. (2013). Available-To-Promise modeling for multi-plant manufacturing characterized by lack of homogeneity in the product: An illustration of a ceramic case. Applied Mathematical Modelling. Vol. 37(5), pp.3380–3398.

Andersson, R. (ed.). (2006). Maol taulukot, 2nd–3rd ed. Keuruu, Finland: Otavan Kirjapaino Oy. 167 p.

APICS. (2013). APICS Dictionary, 14th ed. Chigago: APICS. 206 p.

Blecker, T. & Friedrich, G. (2007). Guest Editorial : Mass Customization Manufacturing Systems. IEEE Transactions on Engineering Management. Vol-54(1), pp.4–11.

Blecker, T. & Friedrich, G. (2006). Mass Customization Challenges and Solutions. New York, NY: Springer. 280 p.

Case company. (2013). Improved Information on Delivery Lead Times. Vantaa: case company. Internal report. 2 p.

Case company. (2014a). Instrument Competitor Summary. Vantaa: case company. Internal report. 4 p.

Case company. (2014b). Internal interim results sharing session. Vantaa: case company. Internal webcast.

Case company. (2012). Order Entry Basics. Vantaa: case company. Internal report. 6 p.

Case company, (2014c). Request Date in SO. Vantaa: case company. Internal report. 7 p.

Chen, C., Zhao, Z. & Ball, M.O. (2001). Quantity and Due Date Quoting Available to Promise. Information Systems Frontiers. Vol. 3(4), pp.477–488.

Cheng, F., Ettl, M., Lin, G. & Yao, D.D. (2002). Inventory-Service Optimization in Configure-to-Order Systems. Manufacturing & Service Operations Management. Vol. 4(2), pp.114–132.

Cheng, T.C.E. & Gupta, M.C. (1989). Survey of scheduling research involving due date determination decisions. European Journal of Operational Research. Vol. 38(2), pp.156–166.

Christensen, C.M. & Raynor, M. (2003). The innovator's solution: creating and sustaining successful growth. Boston, MA: Harvard Business School Press. 304 p.

Cohen, L., Manion, L. & Morrison, K. (2007). Research Methods in Education, 6th ed. London: Routledge Taylor & Francis Group. 638 p.

Corti, D., Pozzetti, A. & Zorzini, M. (2005). A capacity-driven approach to establish reliable due dates in a MTO environment. International Journal of Production Economics. Vol. 104. pp.536–554.

Dickersbach, J.T. (2006). Supply Chain Management with APO, 2nd ed. Berlin: Springer. 502 p.

Easton, F.F. & Moodie, D.R. (1999). Pricing and lead time decisions for make-to-order firms with contingent orders. European Journal of Operational Research. Vol. 116, pp.305–318.

Fogliatto, F.S. & Da Silveira, G.J.C. (2011). Mass Customization Engineering and Managing Global Operations. London: Springer. 378 p.

Fogliatto, F.S., Da Silveira, G.J.C. & Borenstein, D. (2012). The mass customization decade: An updated review of the literature. International Journal of Production Economics. Vol. 138(1), pp.14–25.

Framinan, J.M. & Leisten, R. (2010). Available-to-promise (ATP) systems: a classification and framework for analysis. International Journal of Production Research. Vol. 48(11), pp.3079–3103.

Gordon, V., Proth, J.M. & Chu, C. (2002). A survey of the state-of-the-art of common due date assignment and scheduling research. European Journal of Operational Research. Vol. 139(1), pp.1–25.

Gosling, J. & Naim, M.M. (2009). Engineer-to-order supply chain management: A literature review and research agenda. International Journal of Production Economics. Vol 122(2), pp.741–754.

Hamilton, S. (2002). Maximizing Your ERP System: A Practical Guide for Managers. McGraw-Hill. Available at: http://www.books24x7.com/ [Accessed: March 1, 2015].

Handfield, R.B. & Pannesi, R.T. (1992). An Empirical Study of Delivery Speed and Reliability. International Journal of Operations & Production Management. Vol. 12(2), pp.58–72.

Heikkilä, J. & Ketokivi, M. (2009). Tuotanto murroksessa : strategisen johtamisen uusi haaste, 2nd ed. Helsinki: Talentum. 272 p.

Hill, A. & Hill, T. (2009). Manufacturing operations strategy. 3rd ed. Basingstoke, UK: Palgrave Macmillan. 504 p.

Hill, T. (1993). Manufacturing strategy: the strategic management of the manufacturing function. London: Macmillan. 311 p.

Hopp, W.J. & Spearman, M.J. (2001). Factory Physics, 2nd ed. New York, NY: McGraw-Hill/Irwin. 698 p.

Ideo. (2011). Human centered design toolkit, 2nd ed. 200 p. Available at: http://www.ideo.com/images/uploads/hcd_toolkit/IDEO_HCD_ToolKit.pdf [Accessed: January 8, 2015].

Jääskeläinen, A. (2014). TTA-15090 Tutkimusmetodologia: haastattelut ja harjoitustehtävän esittely. Lecture material. Department of Industrial Management, Tampere University of Technology. 23 p.

Jiao, J.R. & Helander, M.G. (2006). Development of an electronic configure-to-order platform for customized product development. Computers in Industry. Vol. 57(3), pp.231–244.

JYU. (2015). Menetelmäpolku. Available at: https://koppa.jyu.fi/avoimet/hum/menetelmapolkuja/menetelmapolku [Accessed: April 10, 2015].

Kaplan, R.S. & Norton, D.P. (1996). The Balanced Scorecard: Translating Strategy into Action. Harvard Business Press. Available at: http://www.books24x7.com/ [Accessed: February 26, 2015].

Kilger, C. & Schneeweiss, L. (2005). Demand Fulfilment and ATP. In Stadtler, H. & Kilger, C. (eds.). Supply Chain Management and Advanced Planning. Berlin: Springer. pp. 179–195.

Kimo. (2015). Stock and leadtime, Kimo corporation webpage. Available at: http://www.kimouk.com/stock-leadtime [Accessed: March 15, 2015]

Kingsman, B. et al. (1996). Responding to customer enquiries in Make-to-Order companies: problems and solutions. Production. Vol 6(2), pp.195–207.

Koskinen, I., Zimmerman, J., Binder, T., Redström, J., & Wensween, S. (2011). Design research through practice : from the lab, field, and showroom. Waltham, MA: Morgan Kaufmann. 197 p.

Kouri, I. (2014). Tuotannonohjausmenetelmät: ERP-järjestelmien käyttö valmistuksen ohjauksessa. Lecture material. Deparment of Industrial Management, Tampere University of Technology. 98 p.

Lanz, M., Järvenpää. E., Nylund, H., Tuokko, R., Torvinen, S., & Georgoulias, K. (2013). Sustainability and Performance Indicators Landscape. Proceedings of the 2014 24th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM), May 20-23. San Antonio, Texas.

Lödding, H. (2013). Handbook of Manufacturing Control: Fundamentals, Description, Configuration. Heidelberg: Springer. 577 p.

Mikkola, J.H. & Skjøtt-Larsen, T. (2004). Supply-chain integration: implications for mass customization, modularization and postponement strategies. Production Planning & Control. Vol. 15(4), pp.352–361.

Moses, S., Grant, H., Gruenwald, L. & Pulat, S. (2004). Real-time due-date promising by build-to-order environments. International Journal of Production Research. Vol. 42(20), pp.4353–4375.

Nicholas, J. (2010). Lean Production for Competitive Advantage: A Comprehensive Guide to Lean Methodologies and Management Practices. CRC Press. Available at: http://www.books24x7.com/ [Accessed: February 10, 2015].

Olhager, J. (2003). Strategic positioning of the order penetration point. International Journal of Production Economics. Vol. 85(3), pp.319–329.

Olhager, J. (2010). The role of the customer order decoupling point in production and supply chain management. Computers in Industry. Vol 61(9), pp.863–868.

Oracle. (2015). Capable to Promise (CTP), Oracle Applications website. Available at: http://docs.oracle.com/cd/A60725_05/html/comnls/us/mrp/atp02.htm#c_ctp [Accessed: April 7, 2015].

Park, C., Song, J., Kim, J-G., & Kim, I. (1999). Delivery date decision support system for the large scale make-to-order manufacturing companies: A Korean electric motor company case. Production Planning & Control. Vol 10(6), pp.585–597.

Pibernik, R. (2005). Advanced available-to-promise: Classification, selected methods and requirements for operations and inventory management. International Journal of Production Economics. Vol. (93-94), pp.239–252.

Porter, M.E. (1980). Competitive Strategy Techniques for analyzing Industries and Competitors. New York, NY: Macmillan Publishing Co., Inc. 396 p.

Porter, M.E. (2008). Strategy Strategy the Five Competitive. Harvard Business Review. Vol. 86(January), pp.78–94.

Rafiei, H. & Rabbani, M. (2011). Order partitioning and Order Penetration Point location in hybrid Make-To-Stock/Make-To-Order production contexts. Computers and Industrial Engineering. Vol. 61(3), pp.550–560.

Rajaniemi, J. (2012). *Defining and Measuring Lead Time in a Telecommunication Production*. Master of Science thesis. Department of Computer Sciences and Engineering, University of Oulu. 63 p.

Robertson, D. & Ulrich, K. (1998). Planning for product platforms. Sloan management review. Vol. 39(4), pp. 19-31.

Rudberg, M. & Wikner, J. (2004). Mass customization in terms of the customer order decoupling point. Production Planning & Control. Vol. 15(4), pp.445–458.

S+S Regeltechnik. (2015). We are there for you 'round the clock, S+S Regeltechnik corporation webpage. Available at: http://www.spluss.eu/company/24h-shipping/en [Accessed: April 10, 2015].

Sahramaa, T. (2013). Community-Forward Campuses: Fostering the Sense of Community at Universities Through Placemaking. Master of Science thesis. Department of Marketing, Aalto University. 142 p.

Sarmiento, R., Byrne, M., Contreras, L.R. & Rich, N. (2007). Delivery reliability, manufacturing capabilities and new models of manufacturing efficiency. Journal of Manufacturing Technology Management. Vol. 18(4), pp.367–386.

Saunders, M., Lewis, P. & Thornhill, A. (2009). Research Methods for Business Students, 5th ed. Pearson Education. 656 p.

Shuttleworth, M. (2008). Case Study Research Design. Available at: https://explorable.com/case-study-research-design [Accessed: February 12, 2015].

Silveira, G. Da, Borenstein, D. & Fogliatto, F. (2001). Mass customization: Literature review and research directions. International Journal of Production Economics. Vol. 72(49), pp.1–13.

Stadtler, H. (2005). Supply chain management and advanced planning –basics, overview and challenges. European Journal of Operational Research. Vol. 163(3), pp.575–588.

Stadtler, H. & Kilger, C. (2008). Supply Chain Management and Advanced Planning, 4th ed. Springer-Verlag Berlin Heidelberg. 556 p.

Stalk, G. (1988). Time--the next source of competitive advantage. Harvard Business Review. (July-August), pp.41–51.

Stalk, G. & Hout, T.M. (1990). Competing Against Time: How Time-Based Competition is Reshaping Global Markets. Simon and Schuster. 304 p.

Stevenson, W.J. (2012). Operations Management, 11th ed. New York, NY: McGraw-Hill/Irwin. 908 p.

Taylor, D.A. (2004). Supply Chains: A Manager's Guide. Addison-Wesley. Available at: https://books.google.com/ [Accessed: February 20, 2015]. 358 p.

Thermokon. (2015). Products (pdf), Thermokon corporation website. Available at: http://thermokon.su/download/Products_2015_en_issue_date_2015-03-19.pdf [Accessed: April 10, 2015].

Vollmann, T.E. et al. (2005). Manufacturing Planning and Control for Supply Chain Management, 5th ed. Singapore: McGraw-Hill/Irwin. 712 p.

Ward, P.T., McCreery, J.K., Ritzman, L.P. & Sharma, D. (1998). Competitive Priorities in Operations Management. Decision Sciences. Vol. 29(4), pp.1035–1046.

Wei, Y., Chen, Frank., Lee, M., Yan, H., Kong, K. & Ng, C.H. (2010). Divide and Conquer: From MTO to ATO/MTO: A Case Study of an Electronics Manufacturer. In Cheng, T.C.E. & Choi, T.M. (eds.). Innovative Quick Response Programs in Logistics and Supply Chain. Berlin: Springer-Verlag. pp. 331-354.

Womack, J.P. & Jones, D.T. (2003). Lean Thinking Banish Waste and Create Wealth in Your Corporation. London: Simon & schuster. 396 p.

Yin, R.K. (2011). Qualitative Research from Start to Finish. New York, NY: The Guilford Press. 348 p.

APPENDIX A: INTERVIEW QUESTIONNAIRE

Interview Questionnaire

1. Name/Age/Position? How long have you been working in this position? Where did you work before your current position? How long have you been working at the case company?

2. Could you tell, how the product specific FMLTPs are currently decided at the case company? In which phase of the product life cycle/R&D process the FMLTPs are determined? Who are involved in the decision making? What factors are taken into account when a FMTLP is defined?

3. Are you satisfied with the case company's current FMLTPs? Why?

4. Do some products/product families have wrong FMLTPs? Please, provide item codes and your proposal for better FMLTPs.

5. What significance the FMLTPs have for the case company's instrument business? Are they competitive advantage or disadvantage for the case company?

6. Do you see it reasonable to have/need for having differing FMLTPs (e.g.) for particular regions?

7. What factors should have an influence on the FMLTP determination? Should some factors trigger the FMLTP revision (e.g. the phase of the product life cycle, altering market demand, changes in the production capacity, some other reason)?

8. Who are the most important stakeholders to be involved in the FMLTP creation/decisions?

9. How do you see the delivery time as a competitive asset in future? How the market requirements are developing?

10. In your opinion, do we need to keep the FMLTP model or should we have model where manufacturing lead time would be based on currently available capacity? (e.g. Available-to-Promise, ATP) What would be the advantages and disadvantages in each scenario?

11. Is there anything else you would like to add or emphasize?

APPENDIX B: LIST OF THE INTERVIEWS

Interview 1. November 26. 2014, at 10:00-11:00. Case company, Vantaa. Position of interviewee: Regional Sales Manager. Semi-structured interview.

Interview 2. November 26. 2014, at 12:00-13:00. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 3. November 27. 2014, at 13:00-14:00. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 4. November 27. 2014, at 14:30-15:30. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 5. December 1. 2014, at 10:00-11:00. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 6. December 1. 2014, at 14:00-15:00. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 7. December 2. 2014, at 14:00-15:00. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 8. December 2. 2014, at 15:30-16:30. Case company, Vantaa. Position of interviewee: Product Manager. Semi-structured interview.

Interview 9. December 8. 2014, at 12:00-13:00. Case company, Vantaa. Position of interviewee: Regional Sales Manager. Semi-structured interview.

Interview 10. December 9. 2014, at 09:00-10:00. Case company, Vantaa. Position of interviewee: Regional Sales Manager. Semi-structured interview via Lync.

Interview 11. December 9. 2014, at 14:00-15:00. Case company, Vantaa. Position of interviewee: Segment Director. Semi-structured interview.

Interview 12. December 10. 2014, at 10:00-11:00. Case company, Vantaa. Position of interviewee: Regional Sales Manager. Semi-structured interview.

Interview 13. December 11. 2014, at 08:00-09:00. Case company, Vantaa. Position of interviewee: Regional Sales Manager. Semi-structured interview via Lync.

Interview 14. December 11. 2014, at 12:00-13:00. Case company, Vantaa. Position of interviewee: Head of Instrument Factory. Semi-structured interview.

Interview 15. December 11. 2014, at 13:00-14:00. Case company, Vantaa. Position of interviewee: LCM Manager. Semi-structured interview.

Interview 16. December 11. 2014, at 16:00-17:00. Case company, Vantaa. Position of interviewee: Segment Director. Semi-structured interview.

Interview 17. December 12. 2014, at 14:30-15:30. Case company, Vantaa. Position of interviewee: Production Planner. Semi-structured interview.

Interview 18. December 15. 2014, at 17:00-18:00. Home, Tampere. Position of interviewee: Regional Sales Manager. Semi-structured interview via Lync.

APPENDIX C: COMPARISON TABLE